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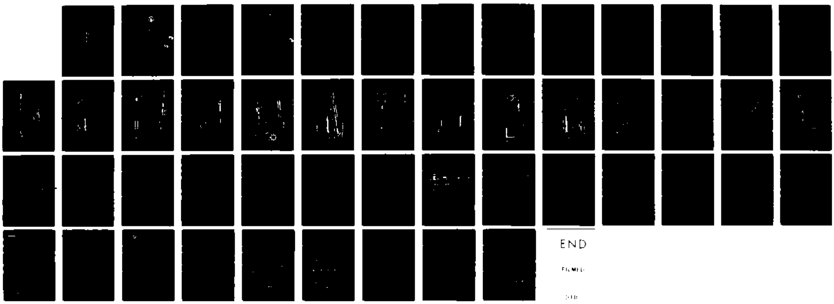

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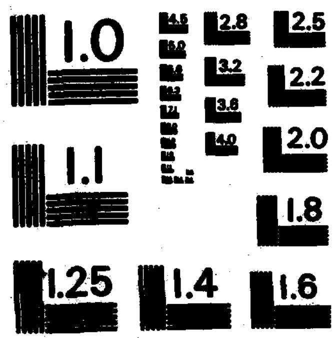
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REPORT NO. NADC-82195-60

AD A120882

A STUDY OF ALTERNATIVE AIRCRAFT FOR INSTALLATION OF THE NAVY STANDARD TOW TARGET SYSTEM

A. Berg
Aircraft and Crew Systems Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

30 JUNE 1982

FINAL REPORT
AIRTASK NO. A6406402-001D-2642580000

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Prepared for
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report analyzes the suitability of various alternative tractor aircraft for both shore and carrier based tow target operations. The investigation considered performance, mechanical/electrical compatibility, and advantages/disadvantages of each type aircraft studied.

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SUMMARY OF RESULTS

Currently, the A-4 and F-4 perform shore based tow target missions, but only the A-6 performs both shore and carrier based tow target operations. This report presents the results of a study of alternative tractor aircraft for shore and carrier based tow target missions. The new alternative aircraft are the S3, F-14, and F-18. Existing installations and studies of the A-7, F-4, A-6, and P-3 were also reviewed.

The S-3 is the recommended alternative for carrier based operations because it meets all of the compatibility requirements outlined herein. The F-18 is a high risk candidate requiring additional study to establish feasibility.

With respect to shore based operations, expanded utilization of the QF-4 and use of the P-3 is feasible. The multiple carriage and NOLO (NO Live Operator) towing capabilities of the F-4 is currently undeveloped. The P-3 was evaluated in a 1966 study and found to be a suitable alternative to the recommended DC-130. The speed, endurance, and multiple system installation capabilities of the P-3 are attractive for shore based target support.

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LIST OF FIGURES

I. BACKGROUND AND INTRODUCTION

This study was performed on a generic basis, such that the depth of detail has not included the specific models of each aircraft. Such detail would be the subject of a design and development program directed towards specific tow system installations.

Currently, the A-4, A-6, and F-4 aircraft are used for tow target operations; however, only the A-6 is used at sea. Alternative aircraft are needed in order to improve operational flexibility, reduce individual aircraft community workload, and ensure a continuing tow target capability. Accordingly, AIRTASK A6406402-001D-2642580000 generated the requirement for an investigation of alternative tractor aircraft for both shore and carrier based tow target operations.

II. DISCUSSION

A. TARGET TOWING EQUIPMENT

The target towing equipment for all aircraft investigated, the Navy Standard Tow Target System (NSTTS), is described in Figure (1). The A/A47U-4 tow target reeling machine launcher system is composed of an RMK-31 reeling machine launcher, a PEK-84 control panel, a TDU-34A tow target (maximum gross weight 225 lbs.) the appropriate towline, and the TDU-34A Target Auxiliary Systems (TAS).

B. AIRCRAFT COMPATIBILITY FACTORS

Up to seven factors were considered in evaluating the target towing capability of candidate aircraft. These factors and their source data are provided as follows:

1. AIRCRAFT/STORE INTERFACE

Ground clearance and aircraft/towreel compatibility were evaluated using reference (a), the Aircraft Stores Interface Manual.

2. EXTERNAL STORES LIMITATIONS

The Naval Air Training and Operating Procedures Standardization (NATOPS) manual for each aircraft was used as the basis for determining mass and moment limitations.

3. ROLL AND YAW TRIM AUTHORITY

An aerodynamic analysis, attached as Appendix (A), was performed to determine roll and yaw trim authority limitations.

4. FUEL AT FIRST ARRESTMENT

The NATOPS manual for each aircraft was used to determine fuel reserves for sea based operations.

5. DUAL CARRIAGE

The feasibility of carrying more than one system was evaluated.

6. TOWING LIMITATIONS

For towing, adequate clearance is required between the towline and all external surfaces of the aircraft during anticipated flight maneuvers. A preliminary analysis of the motion of the towline with respect to the aircraft surface was performed using the data provided in reference (b), an analysis of the tow system on the A-4. For other than the A-4, the data is imprecise; however, there is sufficient information to determine feasibility or a need for further detailed analysis.

7. ELECTRICAL COMPATIBILITY

Each aircraft electrical system was investigated to determine the aircraft/tow system interface capabilities.

C. ALTERNATIVE AIRCRAFT CANDIDATES

1. NEW INSTALLATIONS

Current carrier based aircraft, not previously used for target towing, were investigated in order to select one as an alternative to the A-6. These aircraft are the S-3, F-14, and F-18. A review of a previous study, plus an emerging interest in an alternative to VC squadron A-4 support, resulted in an investigation of the P-3 aircraft.

2. DEMONSTRATED INSTALLATIONS

Towing capability of the A-4, A-6, A-7, and F-4 aircraft has been demonstrated; however, in the interest of completeness, these installations were reviewed.

III. RESULTS

A. NEW INSTALLATIONS

1. F-18

There are three possible locations for the tow system on the F-18 aircraft - centerline, inboard wing (B.L. 88.0), and outboard wing (B.L. 134.28). A centerline installation would provide insufficient catapult or arrested landing deck clearance, and would also result in a towline strike on the fuselage. An outboard wing installation would result in insufficient catapult and arrestment clearance, towline contact with the tail during turns away from the target wing, unsafe transient yaw moment from a towline failure under high load, and, per the telcon report attached as Appendix (B), excess static moment for carrier operations. An inboard wing installation may be feasible per Figures (2) and (3); however there is a high risk of towline contact with the tail, as indicated in Figures (4) and (5). Further interest in the F-18 would require a detailed analysis of potential towline/aircraft structure interference using precise F-18 flight characteristics, and specifying angles of attack and side slips for various gross weights, airspeeds, and maneuvers. Electrical compatibility was not evaluated due to the unavailability of data at this time.

2. F-14

The only location providing ground clearance for the tow system is at B.L. 15.0, per Figures (6) and (7). For this installation, the towline will either strike the fuselage for turns into the target side, or pass through the engine exhaust plume for turns away from the target side per Figures (8) and (9). Electrical compatibility was not evaluated.

3. S-3

The tow system may be installed on either wing station at B.L. 156.1. For port wing installations, clearance between the towreel power unit blades and the Integrated Catapult Control Station (ICCS - located on the port, waist catapults of CVA-69 and later carriers) would be approximately 1 1/2 inches less than the required six inches, as shown in Figures (10) and (11). This is considered to be a minor deficiency; otherwise, the installation meets or exceeds all other mechanical compatibility requirements, including aircraft/towline clearance, as shown in Figures (12) and (13). For electrical requirements, disabling the aircraft auxiliary jettison circuit would make eight existing wires available for multiplexing. There is also a potential for the inclusion of a limited number of wires dedicated to pod systems (including towreels) in a forthcoming airframe change supporting S-3B conversion.

4. P-3

A previous study, excerpts of which are included herein as Appendix (C), established the requirement for an aircraft to replace the DP-2E for the launch, track, and control of aerial targets. Although the study was directed primarily towards powered targets, it stated that, except for high altitude and high airspeed requirements, a tow system installation could handle the complete Navy tow target inventory. The study concluded that the later P-3A was suitable for use as a target launch, track, and control aircraft.

B. DEMONSTRATED INSTALLATIONS

1. F/QF-4

The F-4 is qualified for towing from the centerline station per reference (c), an A-4 and F-4 tow system evaluation. The possibility of towing from the outboard wing station at B.L. 132.5 was evaluated, for either manned or unmanned (NOLO) flights, as shown in Figures (14) and (15). Aircraft-towline clearance appears to be satisfactory per Figures (16) and (17). NOLO towing may offer some interesting capabilities for sophisticated tow systems, such as formation tow or high performance (supersonic) tow, with a reduced risk to a pilot or to the powered target. The aircraft/store interface investigation for carrier operations indicates probable target/deck impact; however, ground clearance is sufficient for shore based operations at ranges. A capability for wing wiring modifications is assumed for the QF-4 and therefore electrical compatibility is assured.

2. A-4/TA-4

The A-4 is approved for target towing using the centerline station, per reference (c). There are no significant operational limitations for tow target operations with the A-4 aircraft.

3. A-7

The A-7 is qualified to carry the tow system at B.L. 136.628, per reference (d), an A-7 tow system evaluation. Bank angle is restricted to 60 degrees while towing, and a dummy store must be carried on the opposite wing to offset excess static moment.

4. A-6

The A-6 aircraft is approved to carry the tow system at either the inboard wing station (B.L. 95.0) or the outboard wing station (B.L. 141.0), per reference (e), an A-6 tow system evaluation. Maximum bank angle is restricted to 45 degrees while towing.

CONCLUSIONS

1. The S-3 is the best alternative aircraft for single or dual carriage, land or carrier based tow target operations, and represents the lowest risk and most cost effective choice for further evaluation.

2. The A-6 can be used for single or dual carriage, land or carrier based operations.

3. Use of the A-7 is feasible for single or dual carriage land based operations, marginally feasible for single carriage carrier operations, and not feasible for dual carriage carrier operations.

4. Use of the QF-4 is feasible for land based single or dual carriage tow target missions using the outboard wing station. Mission capabilities include supersonic tow, formation tow, NOLO tow at ranges, and with the installation of a 600-gallon centerline fuel tank, extended time on station.

5. The feasibility of using the F-18 aircraft cannot be confirmed without a detailed analysis of the towline in flight.

6. Target towing with the F-14 aircraft is considered infeasible, since, for all but minor course correction turns, the towline will either strike the fuselage or enter the engine exhaust plume.

7. The P-3, previously evaluated in a 1966 study, was found to be a suitable alternative to the recommended DC-130. The P-3 can adequately perform shore based target support missions because of its speed, endurance, and multiple system installation capabilities.

RECOMMENDATIONS

1. Initiate engineering development of the A/A47U-4 tow target system installation on the S-3 aircraft for carrier and land based tow target missions, culminating in a carrier suitability flight test program and eventual approval for fleet operations. This recommendation is in response to a specific need for an alternative to the A-6.

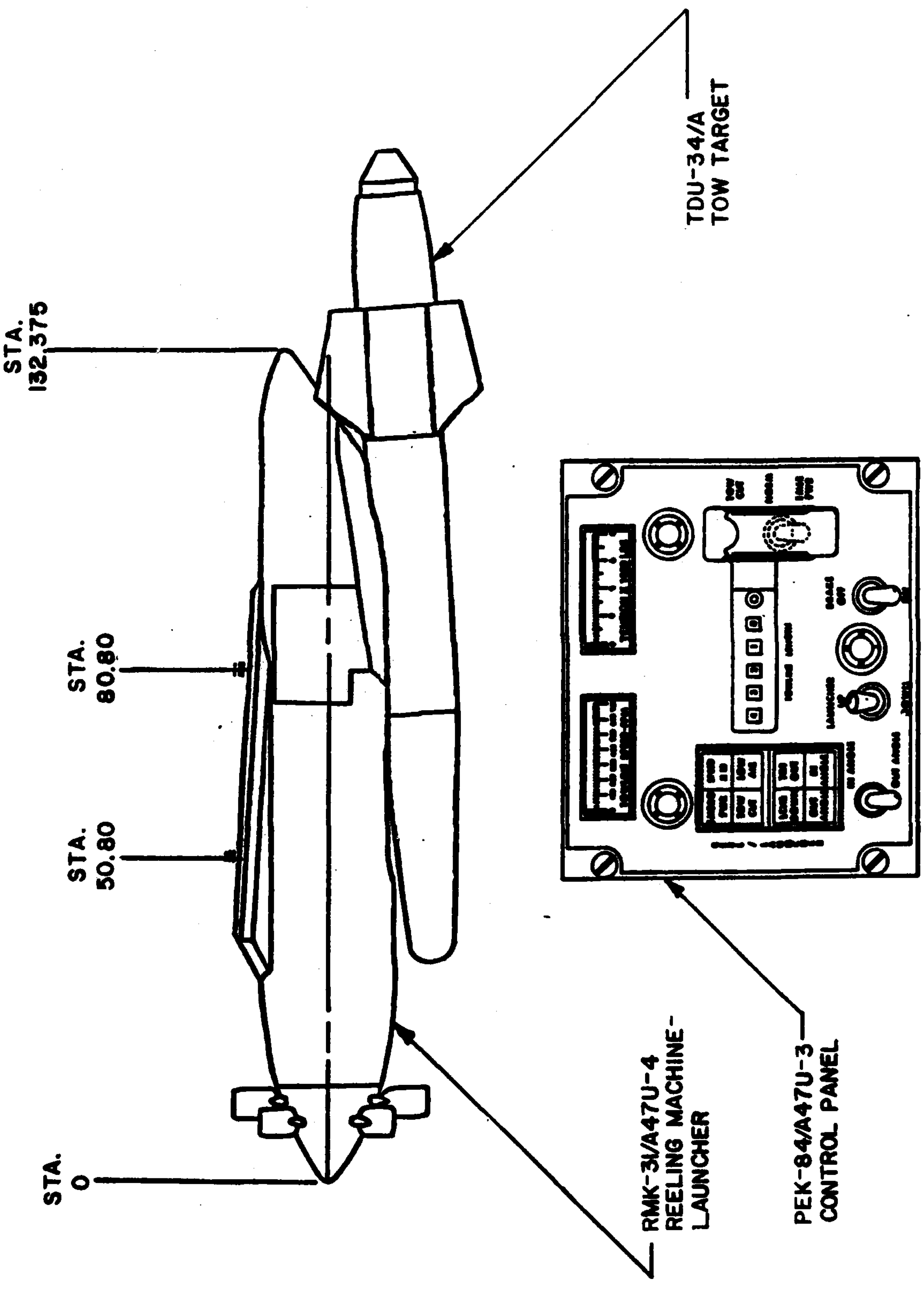


FIGURE I - NSTTS DEFINITION

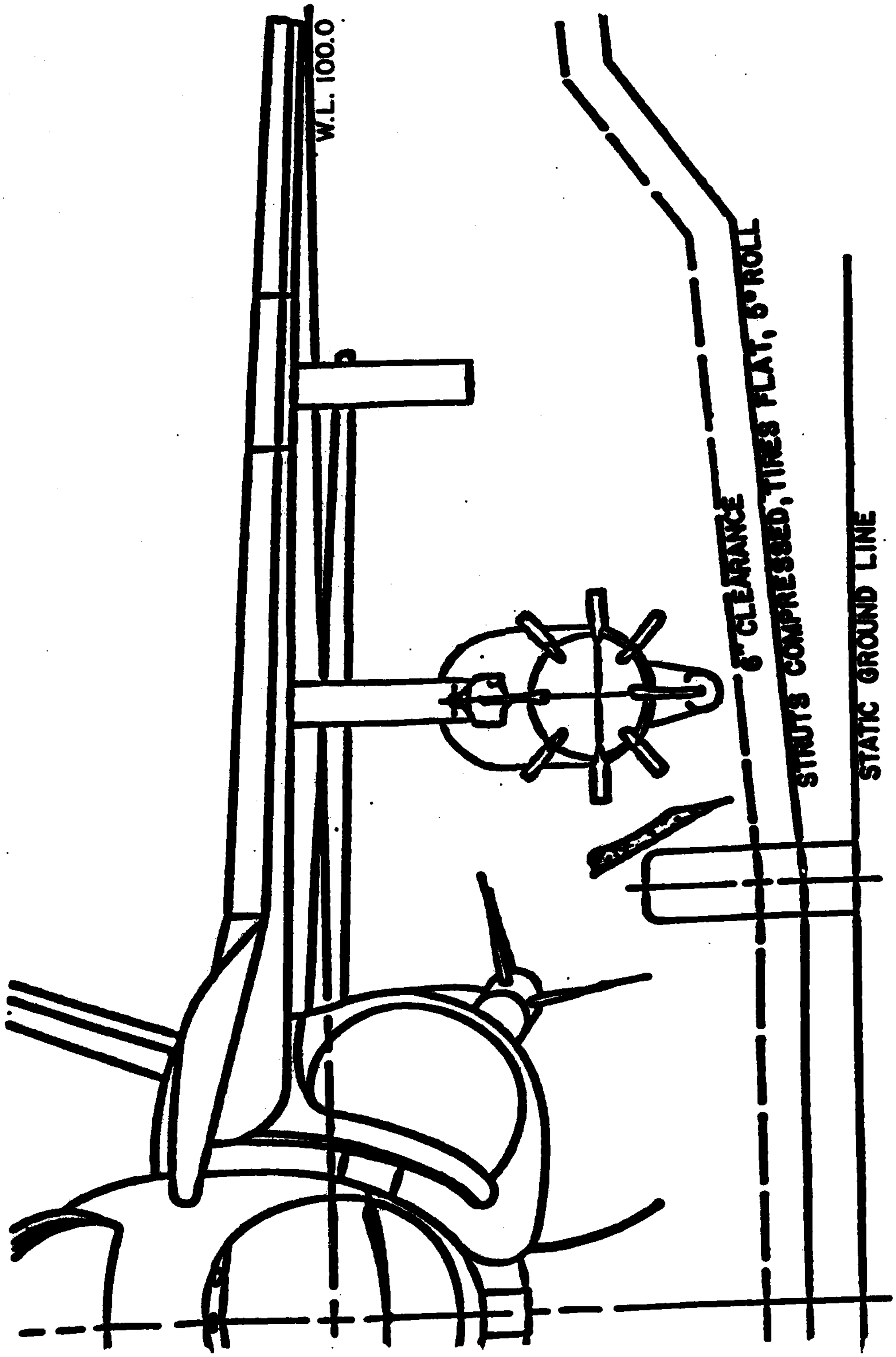


FIGURE 2 - F-18 NSTTS INSTALLATION, FRONT VIEW

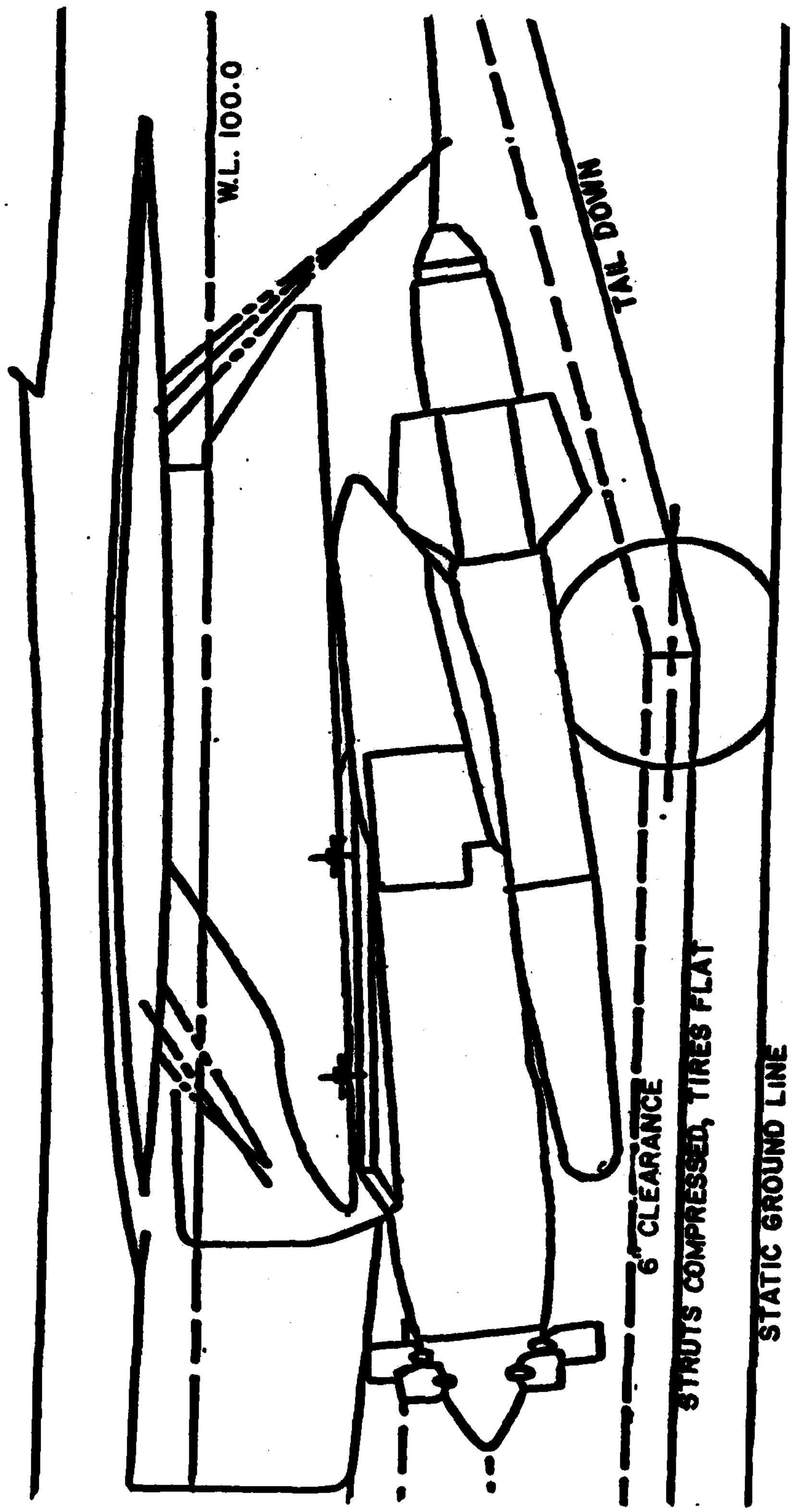


FIGURE 3 - F-18 NSTTS INSTALLATION, SIDE VIEW

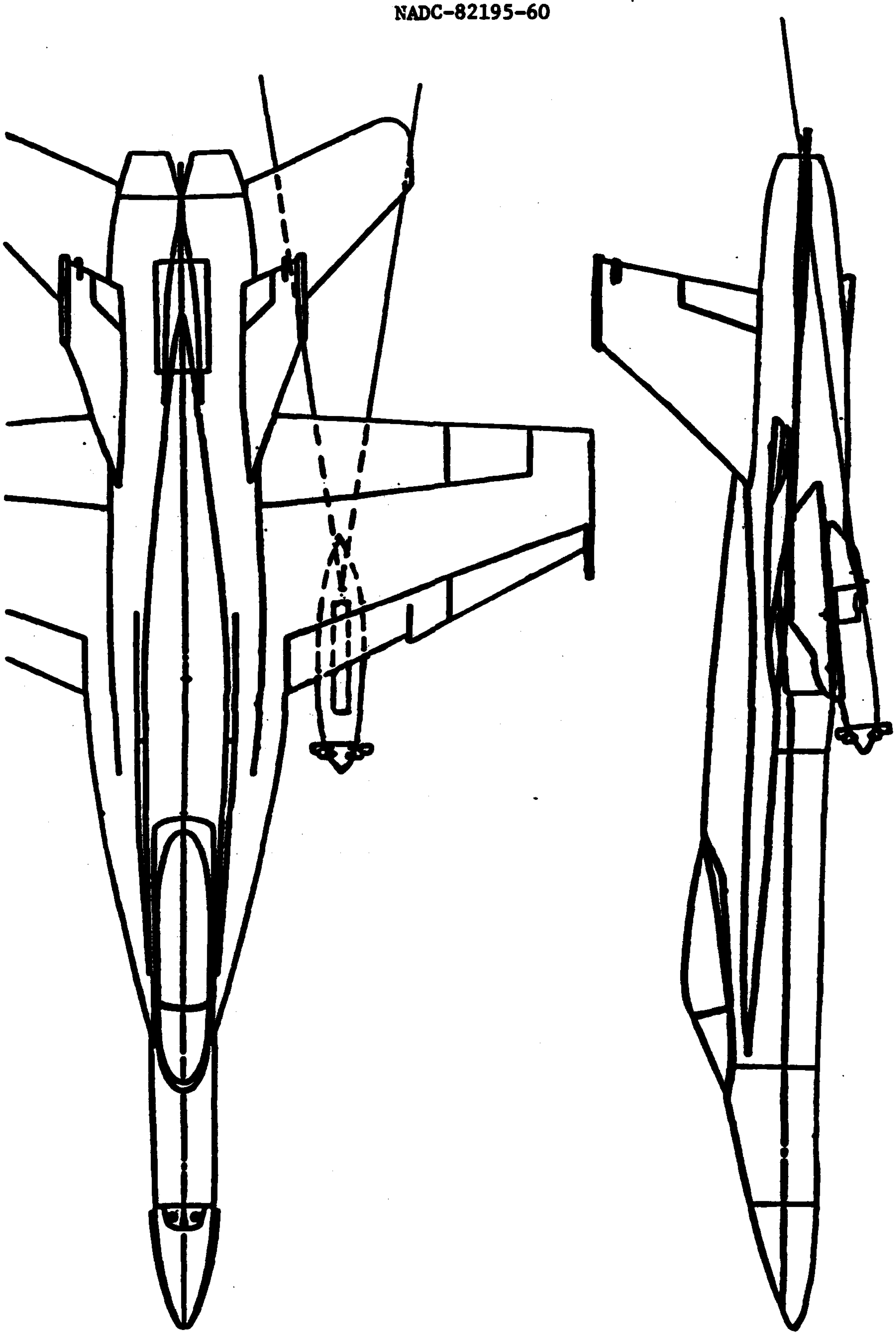


FIGURE 4 - F-18 - EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

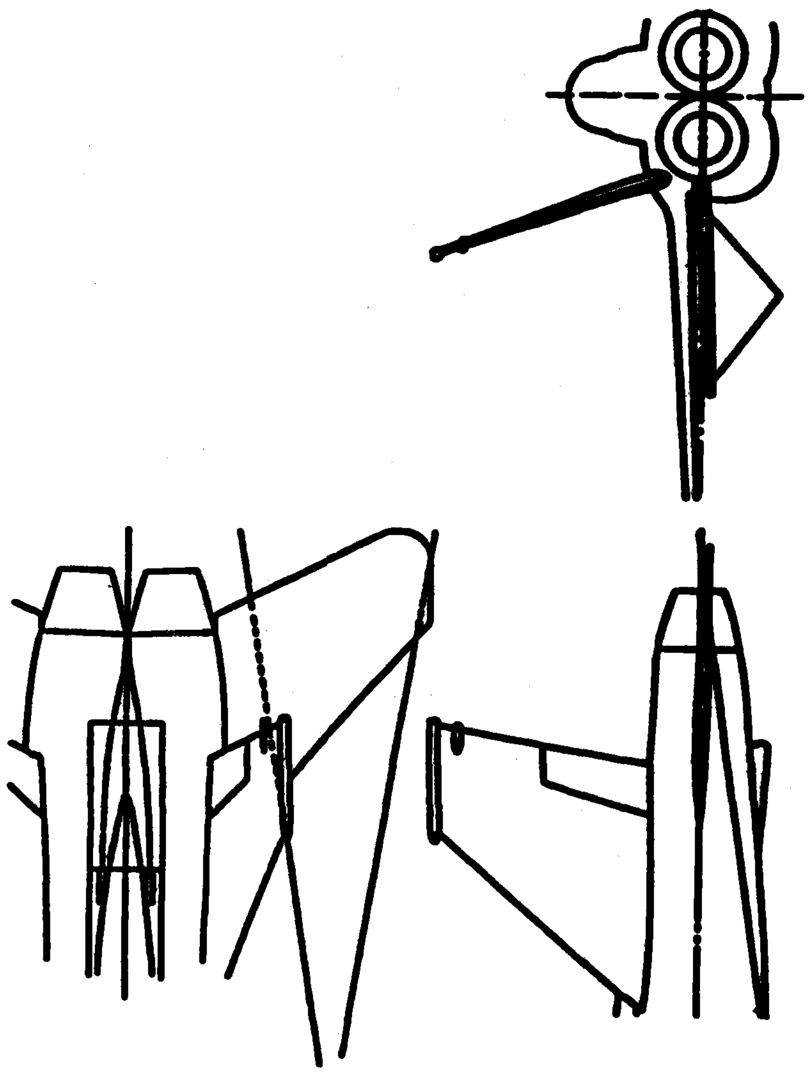


FIGURE 5 - F-18 TAIL–EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

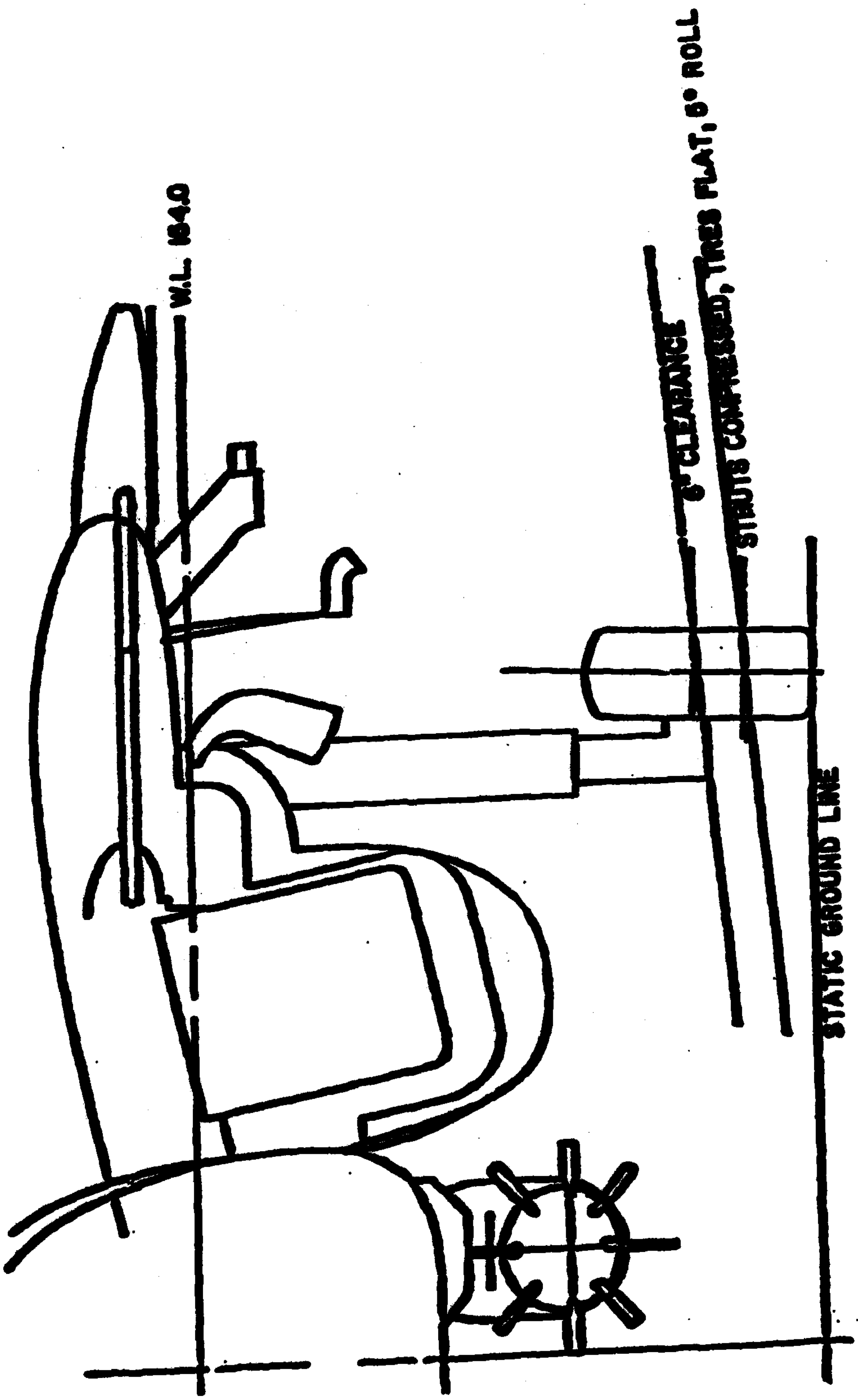


FIGURE 6 - F-14 NSTTS INSTALLATION, FRONT VIEW

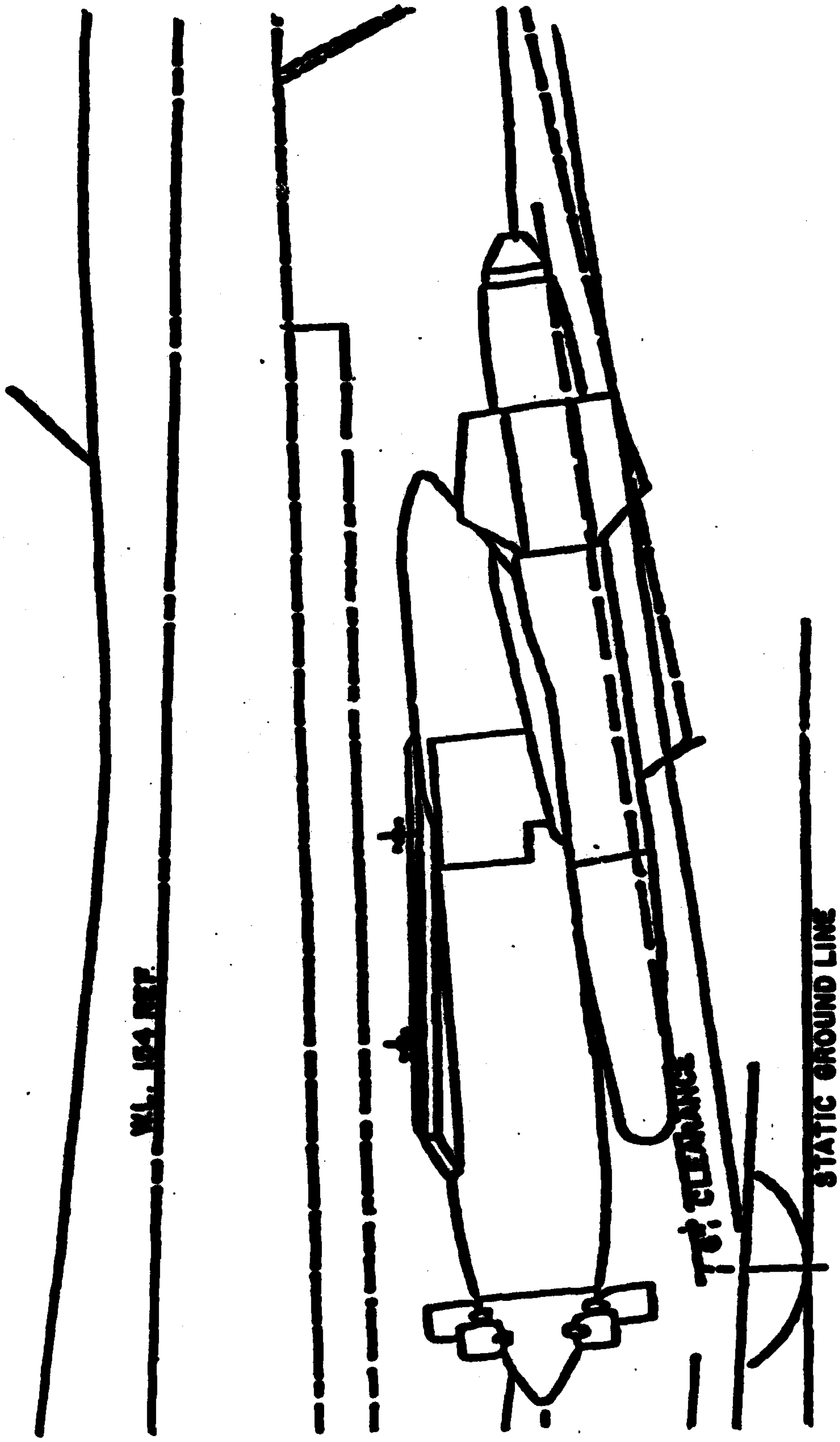


FIGURE 7 - F-14 NSTTS INSTALLATION, SIDE VIEW

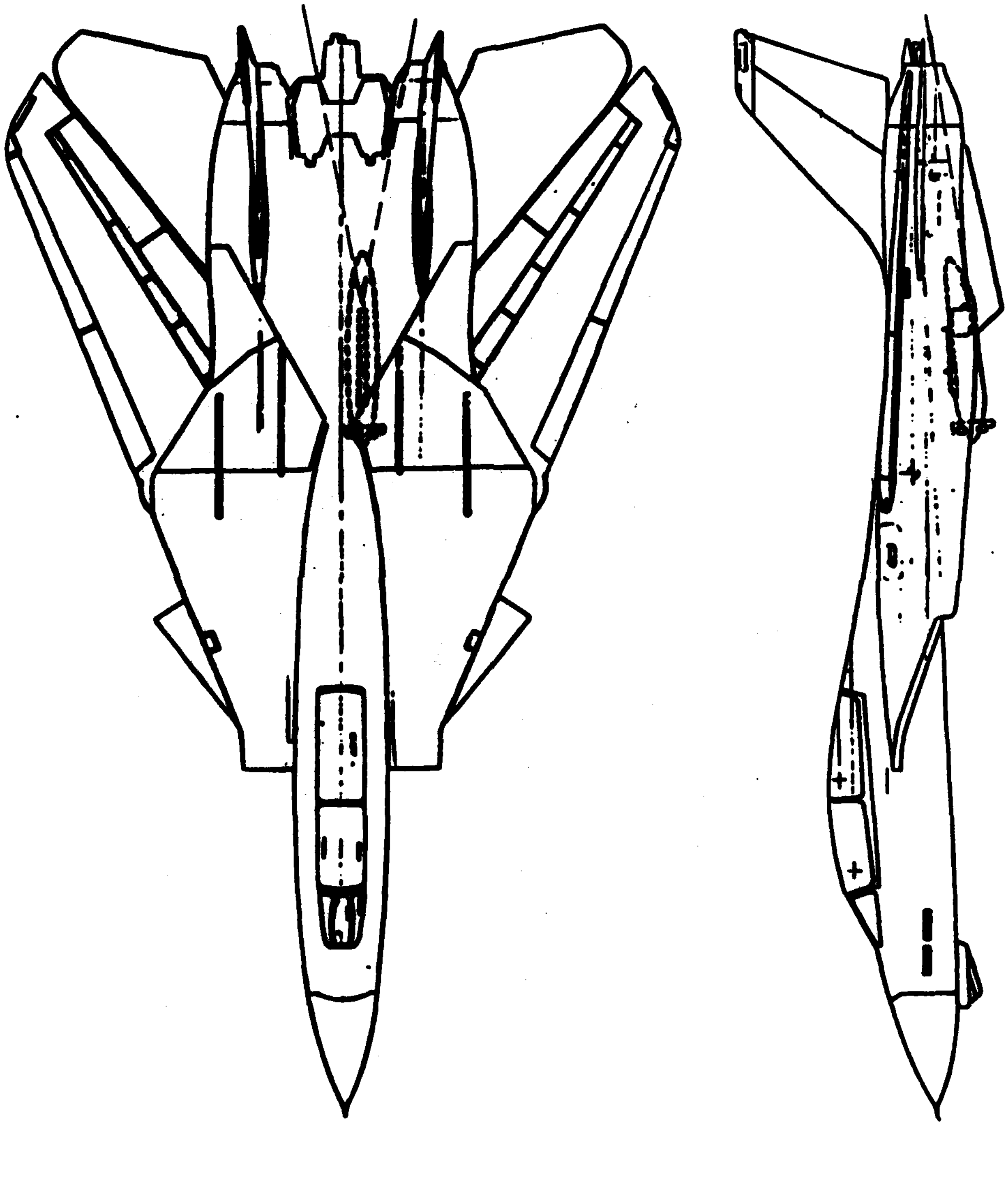


FIGURE 8 - F-14 - EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

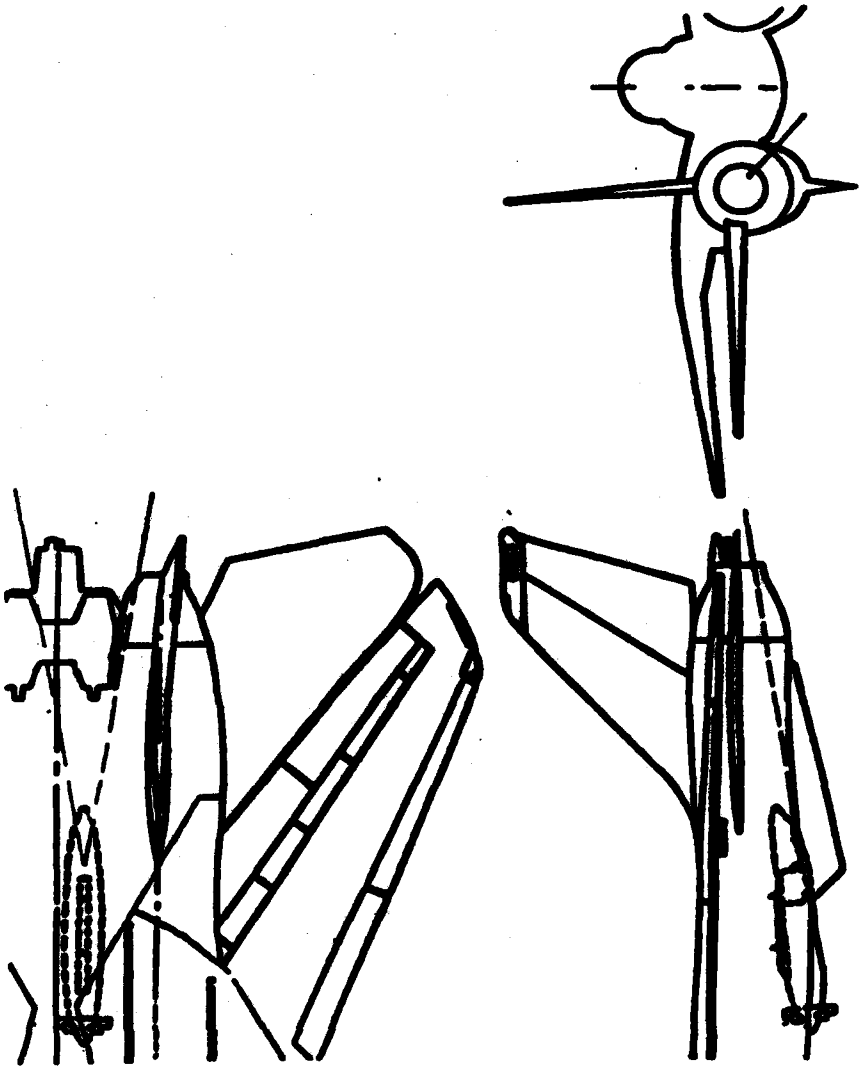


FIGURE 9 - F-14 TAIL - EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

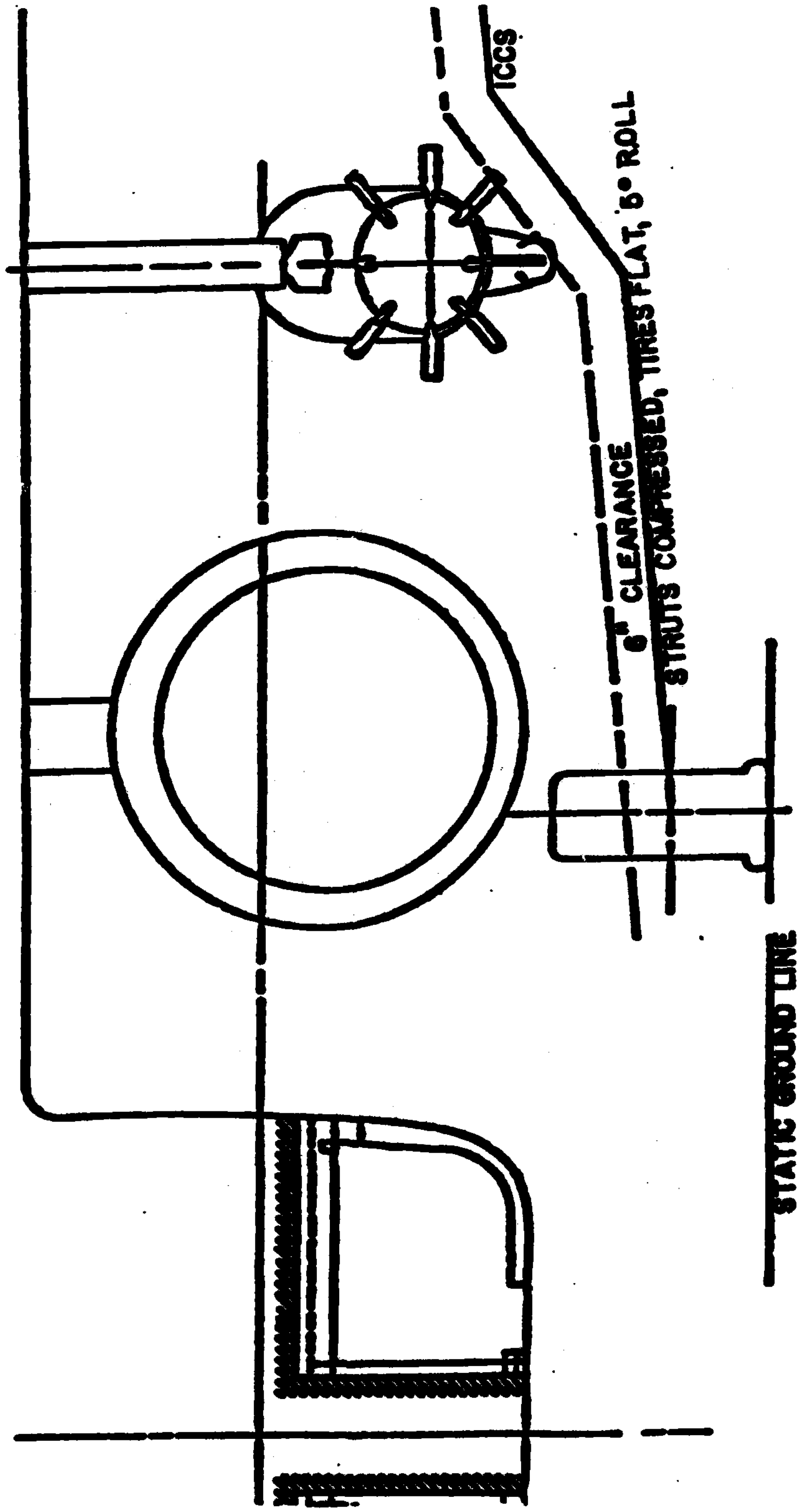


FIGURE 10 - S-3 NSTTS INSTALLATION, FRONT VIEW

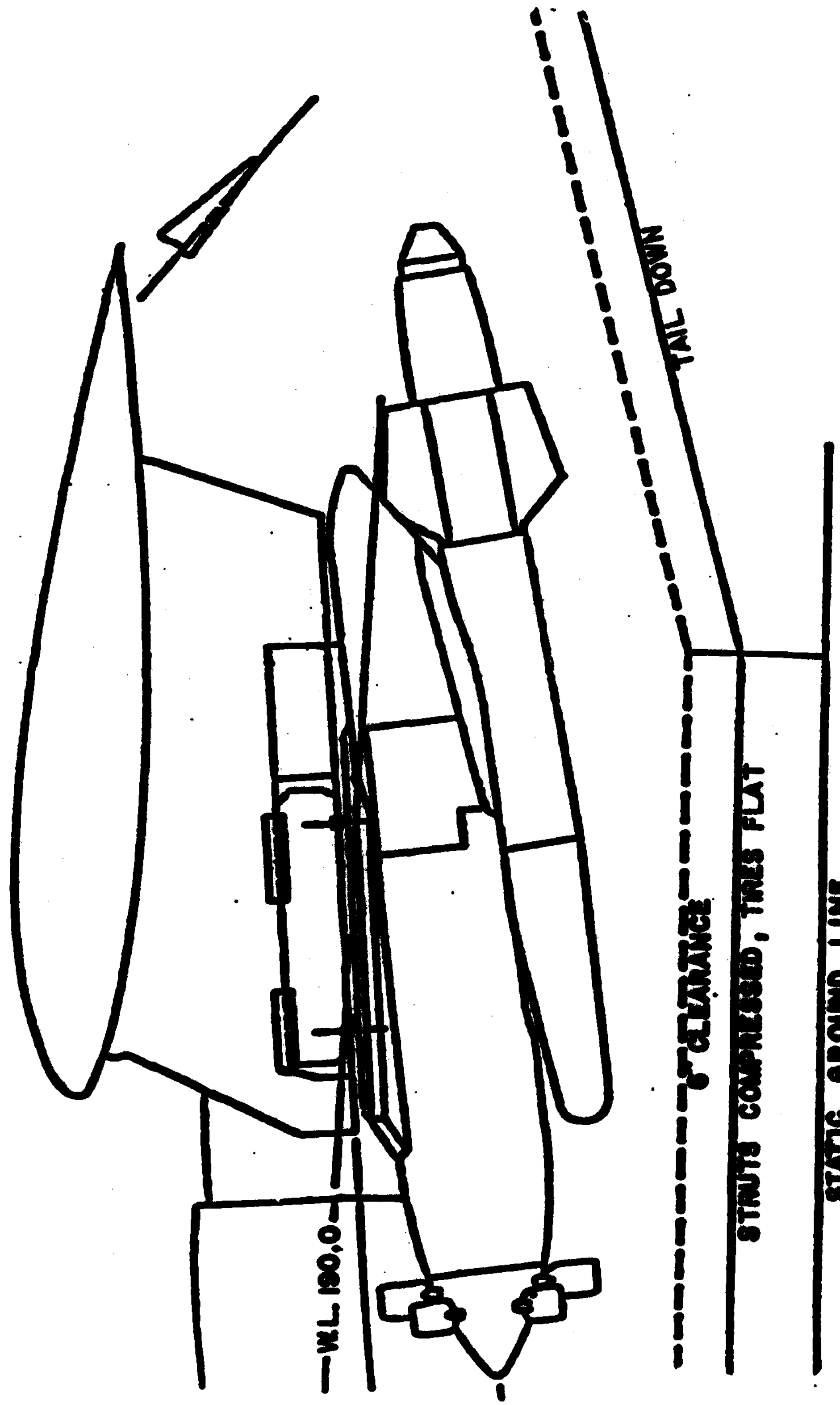


FIGURE II - S-3 NSTTS INSTALLATION, SIDE VIEW

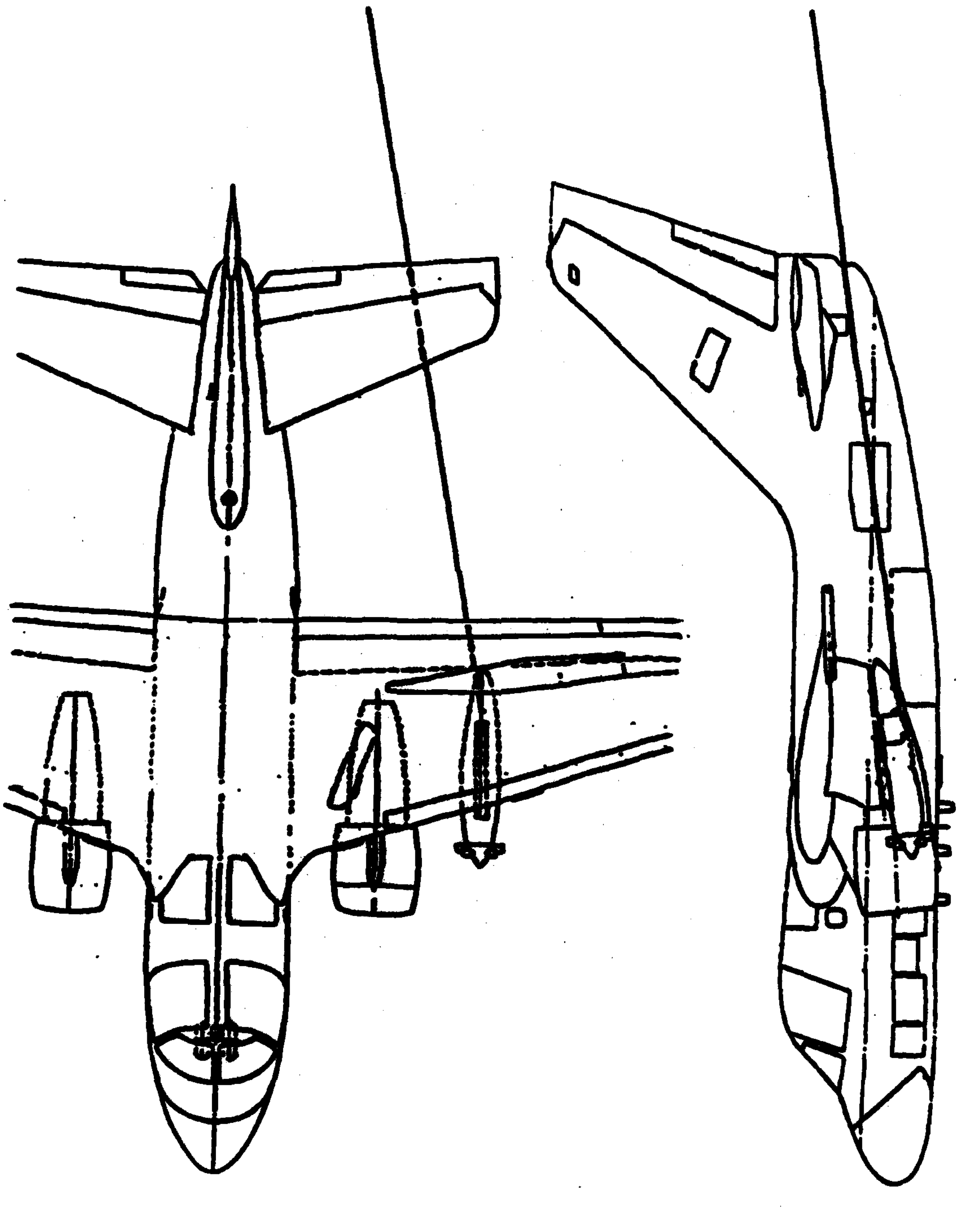


FIGURE 12 - S-3 - EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

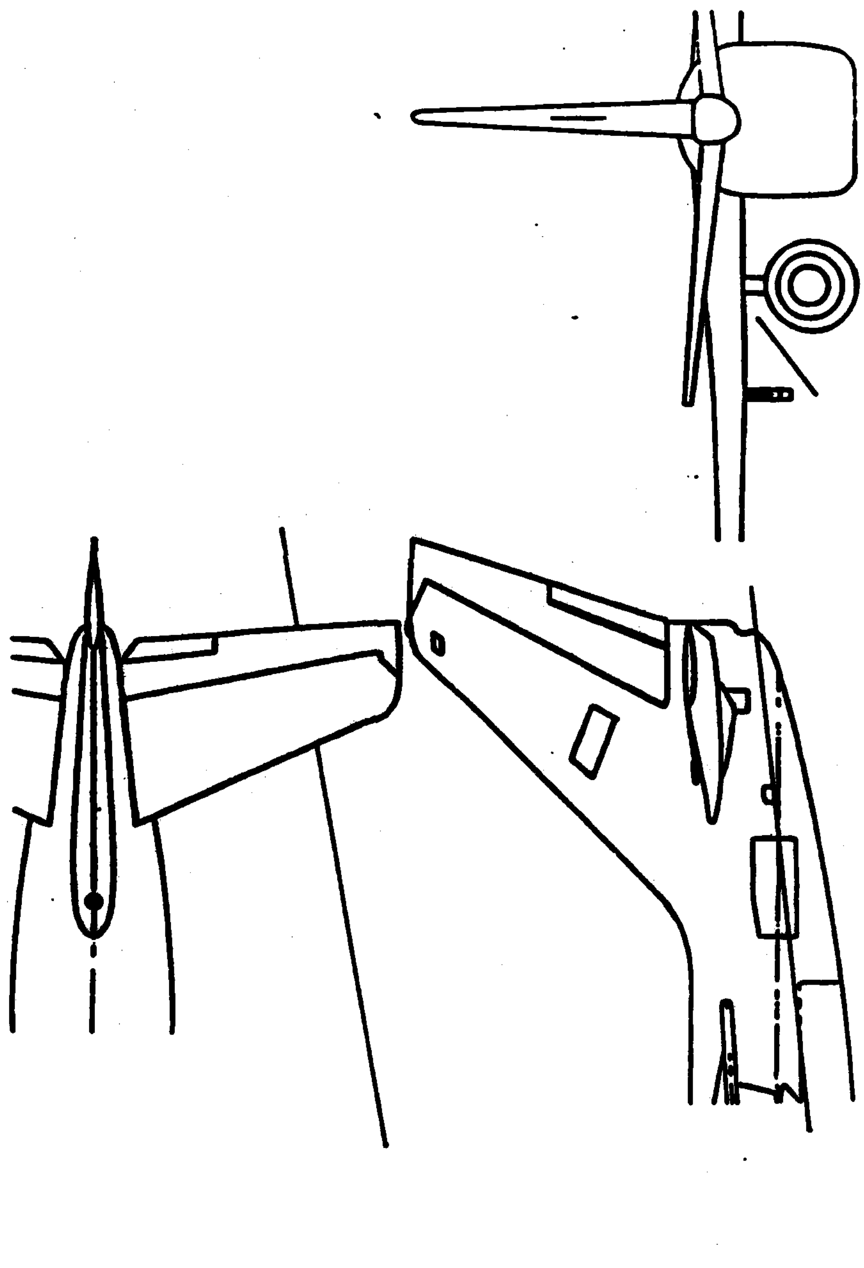


FIGURE 13 - S-3 TAIL-EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

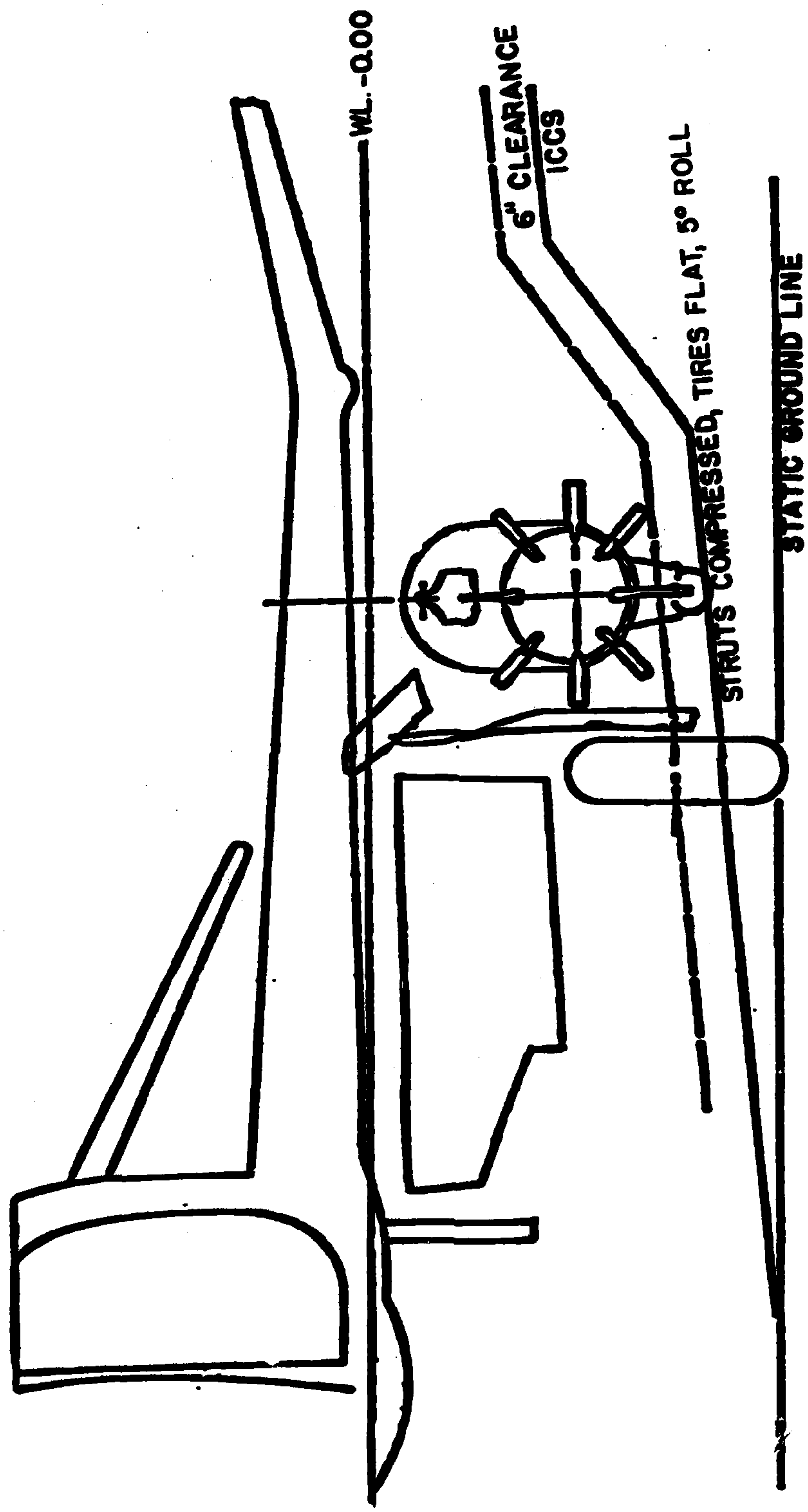


FIGURE 14 - QF-4 NSTTS INSTALLATION, FRONT VIEW

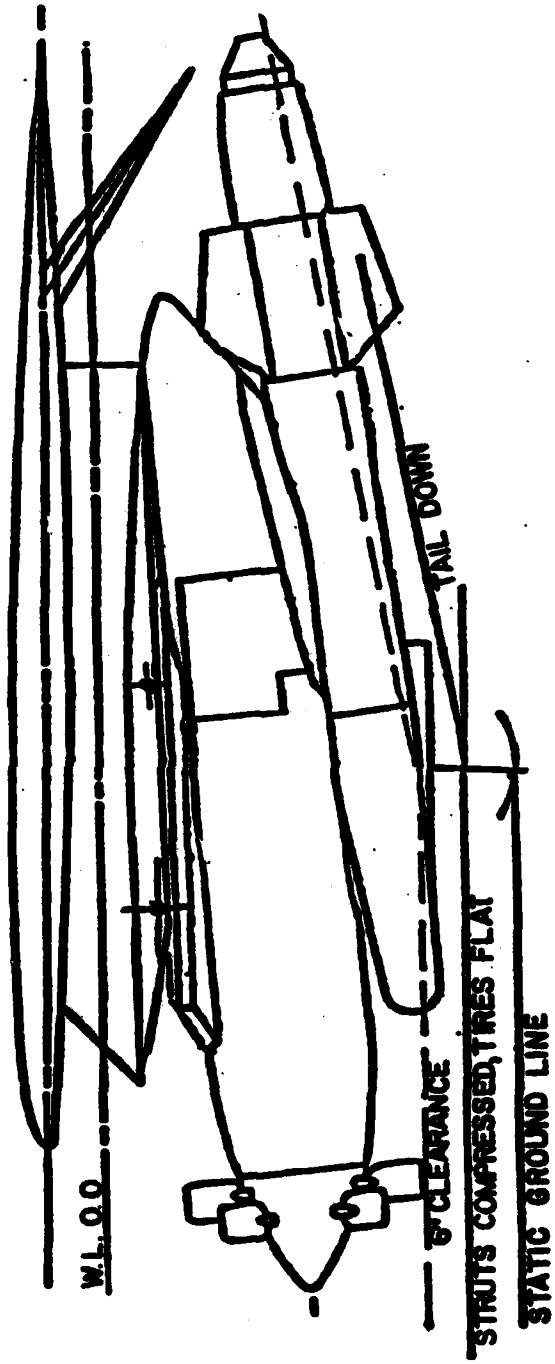


FIGURE 15 - QF-4 NSTTS INSTALLATION, SIDE VIEW

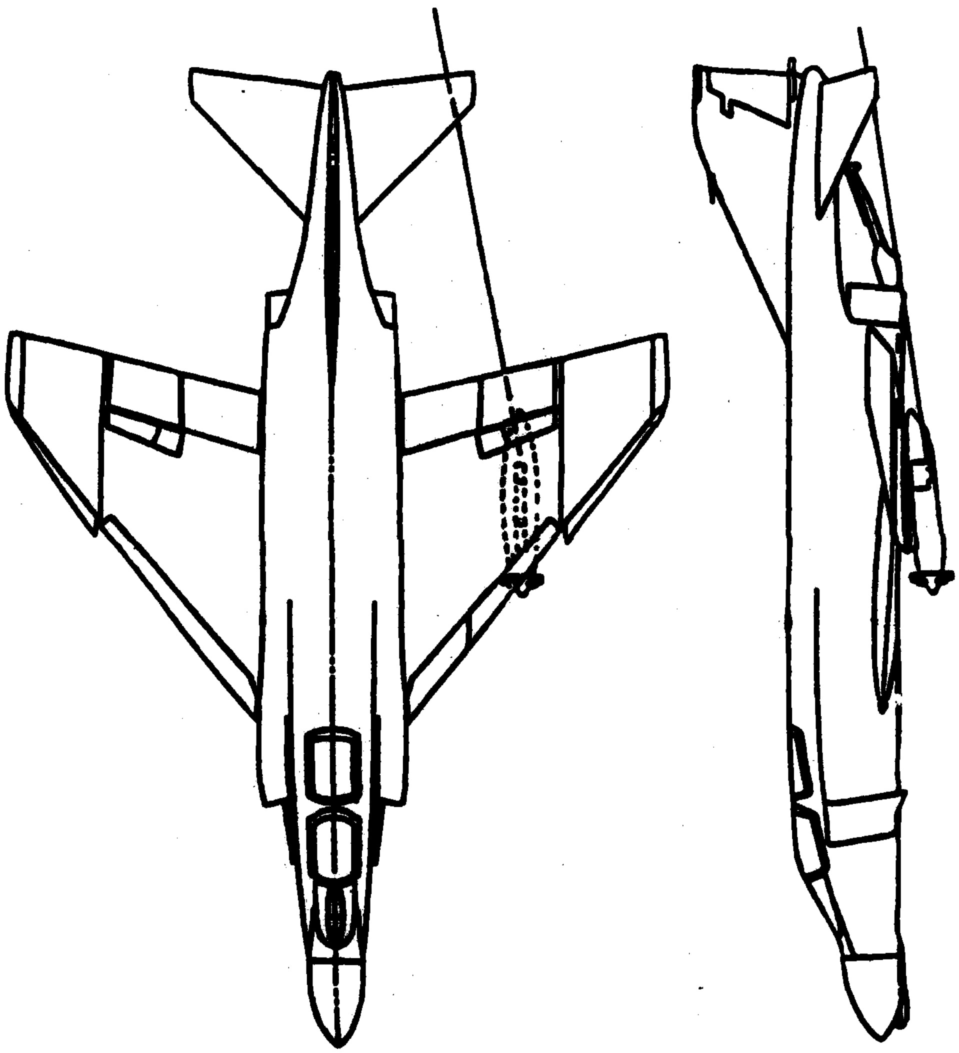


FIGURE 16 - QF-4 - EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

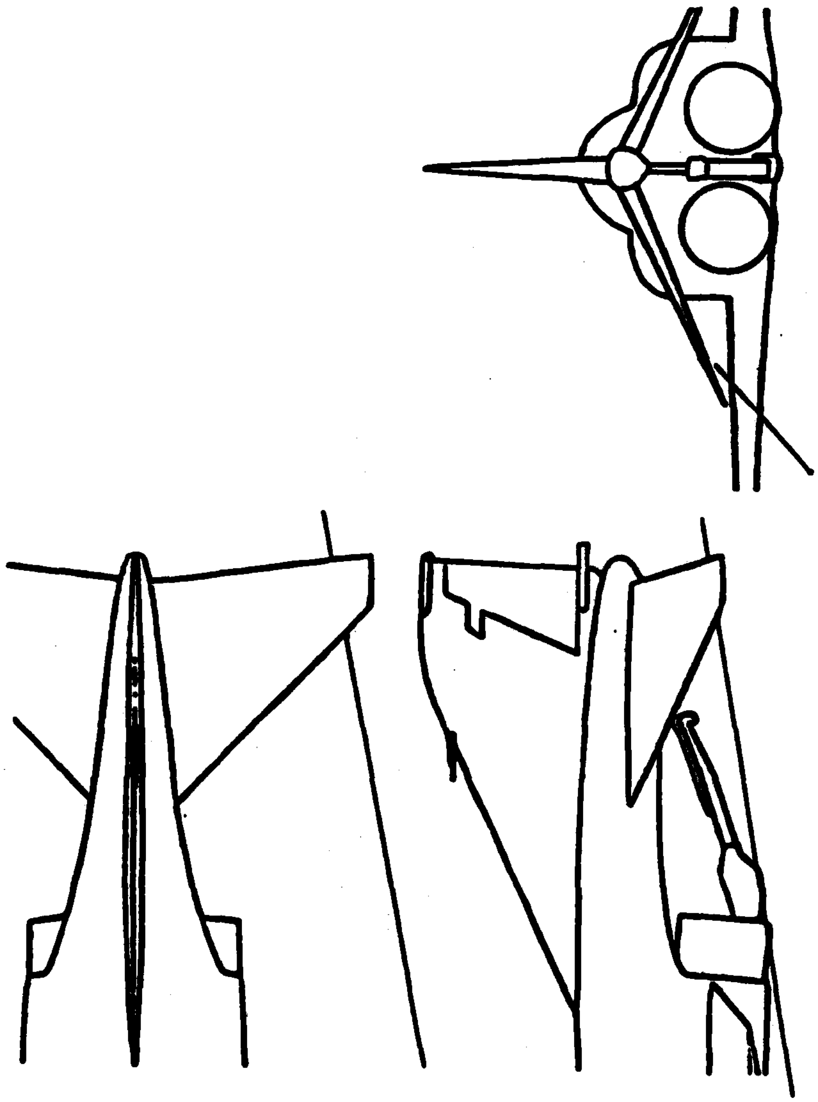


FIGURE 17 - QF-4 TAIL-EXTREME TOWLINE POSITION, MANEUVERING FLIGHT

REFERENCES

(a) Aircraft Stores Interface Manual (ASIM), JTCG/ALNNO WP-12-1, prepared by the Naval Weapons Center, China Lake, California.

(b) D. W. Carroll, "Aeromechanical Analysis of a Tow Target System Installed on the A-4 Airplane," NADC Report No. NADC-74150-30, 4 September 1974.

(c) R. K. Maughlin, C. A. Noell, G. R. Ryan, "A-4 and F-4 RMK-19 Tow Reel Compatibility and Target Qualification Evaluation," NATC Report No. SY-181R-77, 18 November 1977.

(d) R. K. Maughlin, C. A. Noell, "A-7A and A-7B RMK-31 General Purpose Reeling Machine and Launcher Compatibility and Target Qualification Evaluation," NATC Report No. SY-155R-78, 7 February 1979.

(e) Maj. C. F. Bolden, C. A. Noell, "Evaluation of the RMK-31 General Purpose Reeling Machine Launcher and Targets on the A-6E Airplane," NATC Report No. SY-66R-80, 25 April 1980.

APPENDIX A

TECHNICAL MEMORANDUM

EVALUATION OF S-3A AND F-18 AIRCRAFT TRIM CAPABILITY FOR TOW TARGET OPERATION WITH WING MOUNTED LAUNCHER

AIRCRAFT AND CREW SYSTEMS TECHNOLOGY DIRECTORATE
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA 18974

6053
26 FEB 1982

MEMORANDUM

From: Mr. C. Henderson (6053)
To: Mr. D. Carroll (6054)
Via: Mr. J. W. Clark (6053)

Subj: Evaluation of S-3A and F-18 Aircraft Trim Capability for Tow Target Operation with Wing-Mounted Launcher

Ref: (a) TM VT-TM-1887, "Data Required to Determine Yaw Trim Authority of the A-6 and A-7A Aircraft When Carrying a Wing Mounted Reeling Machine Launcher" of Oct 1976
(b) Verbal Communication with Mr. D. Carrol of Feb 1982
(c) Lockheed Report LR23462-1 "A-3A Aerodynamic Stability and Control & Flying Qualities" Report, of Dec 1971
(d) McAIR Report MDCA3957 "F-18 Aerodynamic Stability and Control & Flying Qualities" , of Jul 1979

Encl: (1) Analysis of S-3A & F-18 Trim Capability for Tow Target Operations with Wing-Mounted Launcher of 26 Feb 1982

1. As part of a study to assess new candidate aircraft for tow target compatibility, the trim control capabilities of the S-3A and F-18 aircraft were examined for suitability with an asymmetric wing-mounted Launcher/ Tow Target. Details of the analysis & results are presented in enclosure (1).

2. The steady-state trim analysis shows that the S-3A, with a target launcher installed at wing station 156, has ample rudder and aileron trim capability for captive flight and for towing in normal operation. With one engine failed on the same side as the launcher, towing speeds above 200 kts. are acceptable with maximum cable tensions up to 3,000 lbs. The out-of-trim yaw/roll transient following a cable break with 3,000 lb. tension has not been examined; however, resulting moments are of the same order as that due to an engine failure in the same flight conditions.

3. Analysis of the F-18 with target launcher installed at wing station 88 also indicates acceptable control margins in captive flight and at towing speeds above 250 kts. with cable tensions up to 3,000 lbs. The out-of-trim moments due to cable break with a tension of 1,500 lbs. are of the same order as that due to engine failure. At cable tensions between 1,500 and 3,000 lbs., yaw/roll transients following cable break may require further evaluation for flight safety.

C. Henderson

C. HENDERSON

Copy to:
6011: A. Berg
605
605DF
6053
6054
6053: C. Henderson;bm;2221

AIRCRAFT AND CREW SYSTEMS TECHNOLOGY DIRECTORATE
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA 18974

6053
26 FEB 1982

S-3A Aircraft Trim Capability With Wing Mounted Launcher/Tow Target

An evaluation of the S-3A aircraft was made to determine yaw and roll trim capability to control the assymmetric loading due to wing mounting of a launcher/tow target. The results are presented in Figures 1 thru 3. Results are based on an A47U-4 GPRML launcher mounted on one wing at station 156. Drag estimates for the GPRML launcher and stowed target were obtained from reference (a). The resulting yawing moment due to drag is very small over the speed range as shown in Figure 1. The major yaw trim requirement occurs with the target reeled out and cable tensions due to drag and maneuvers acting. Two levels of cable tension were evaluated: 1,500 lbs. and 3,000 lbs. The 3,000 lb. cable tension condition is considered to be an upper limit occuring only at the higher end of the speed range (reference (b)). As shown in Figurel, ample trim capability is provided by the S-3A yaw (rudder tab) trim system for all conditions investigated. Rudder trim authority (at full trim tab setting $\delta_t = \pm 25^o$) and the resulting yaw trim capability are based on data from reference (c).

Rudder trim required and available were also determined for the combined condition of asymmetric power (engine failed on the tow target side) and tow target loading. Results are shown in Figure 2. Trim capability is provided for all speeds above approximately 180 kts. for the worst case of a 3,000 lb. cable tension. Also as indicated by the results of Figure 2, the out-of-trim condition resulting from cable break, with Tc=3,000 lbs., is of the same order as that due to the one engine out. Thus ensuing yaw transients due to cable break, although not investigated in this study, would appear to be acceptable.

Similar analyses were made for the roll trim requirements and capability as shown in Figures 3 and 4. Roll trim requirements are less severe than for yaw, showing ample trim margins over the speed range. A weight of 1,300 lbs. for launcher and cable and 225 lbs. for target were used in the analysis. A maximum negative airload due to pod incidence and wing-pod interference, estimated to be $C_L = -.5$ based on pod body planform area, was also used in the trim requirements calculations. A cable angle of 4^o relative to the fuselage body axis was used in the evaluation of rolling moments due to cable tension.

F-18 Aircraft Trim Capability With Wing Mounted Launcher/Tow Target

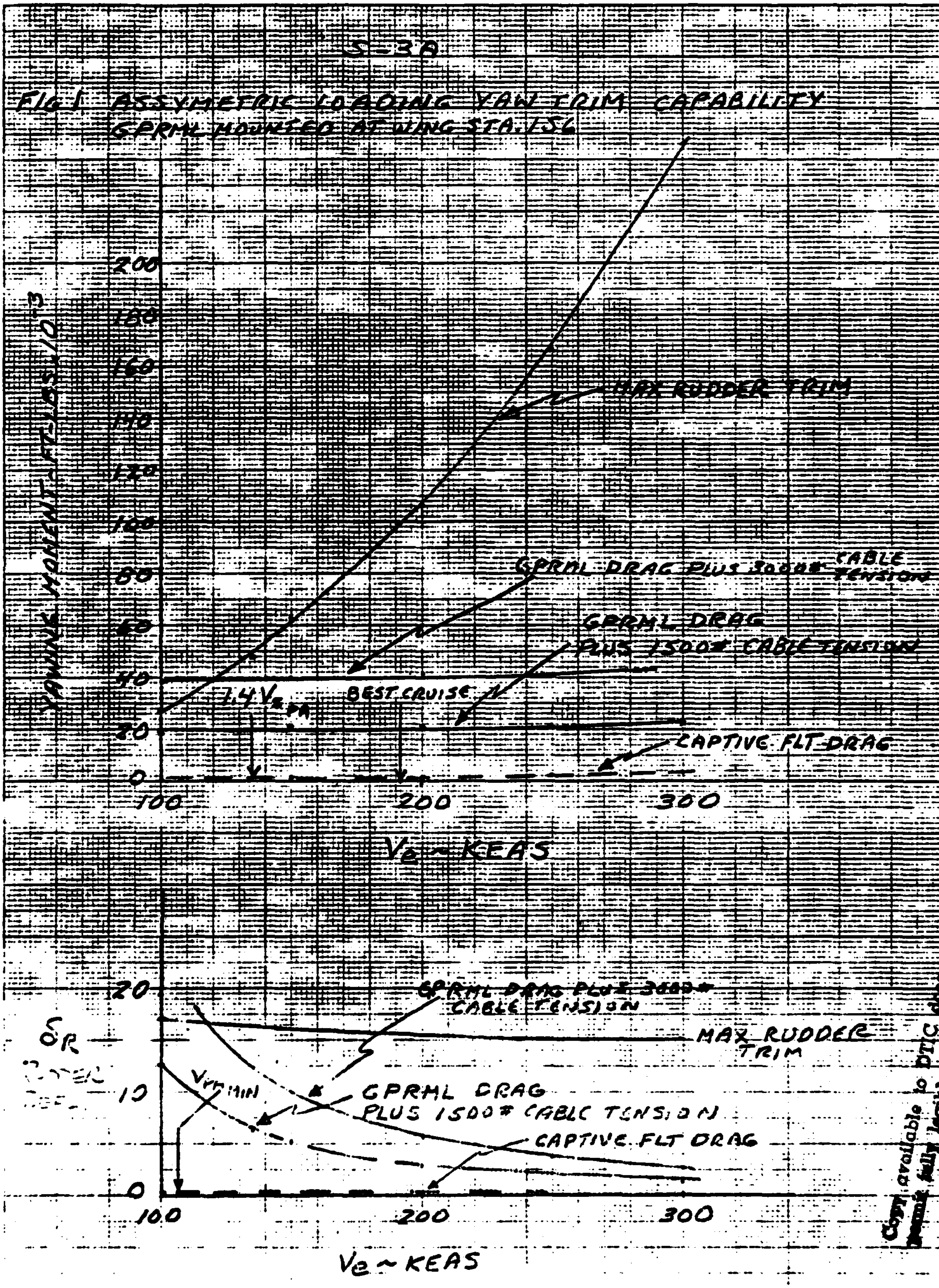
A similar evaluation of the F-18 aircraft was made to determine yaw and roll trim capability for target towing operations with an asymmetric wing mounted A47U-4 GPRML launcher. Results are based on the launcher mounted at wing station 88. Drag estimates for the launcher were obtained

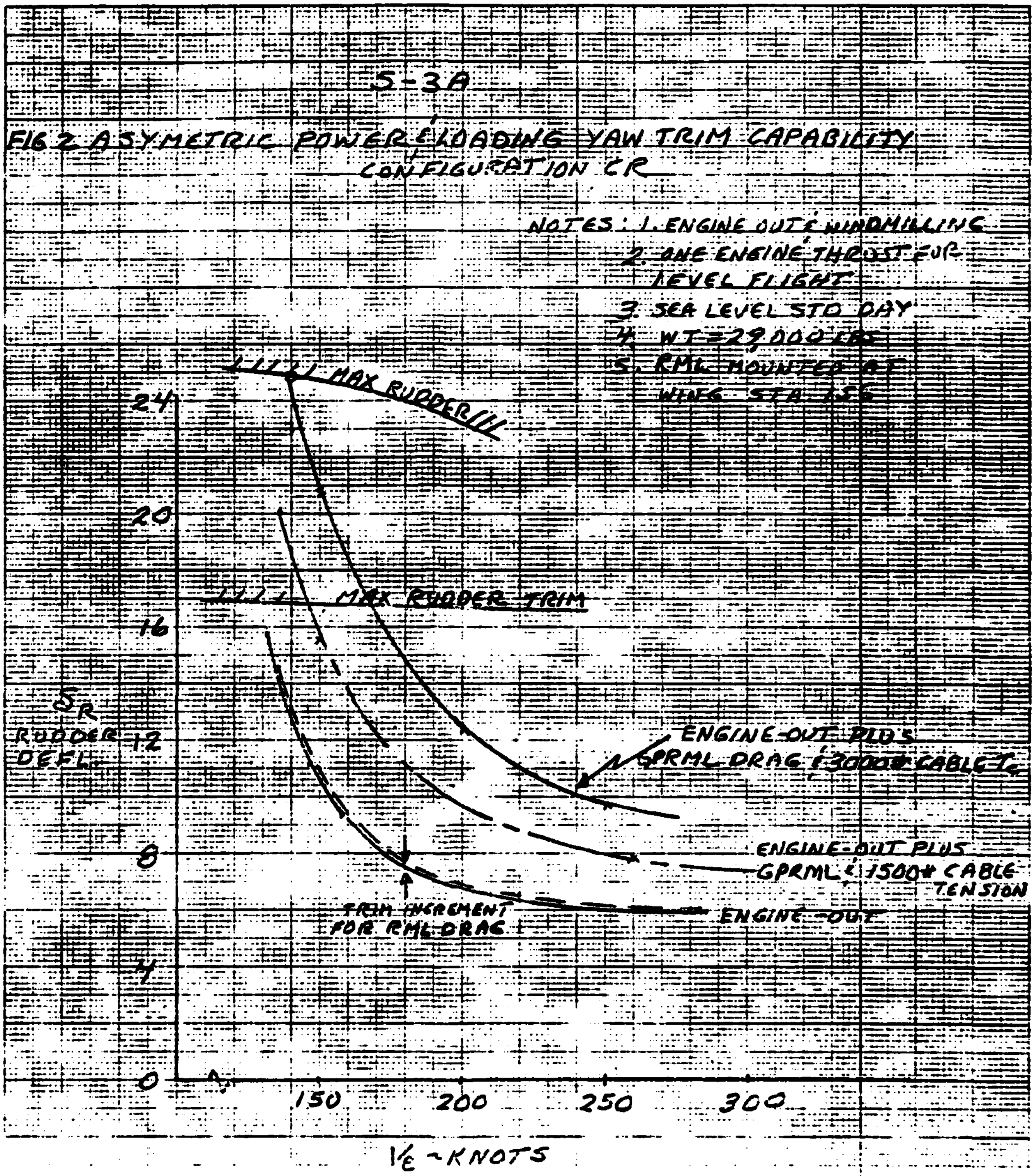
Enclosure (1)

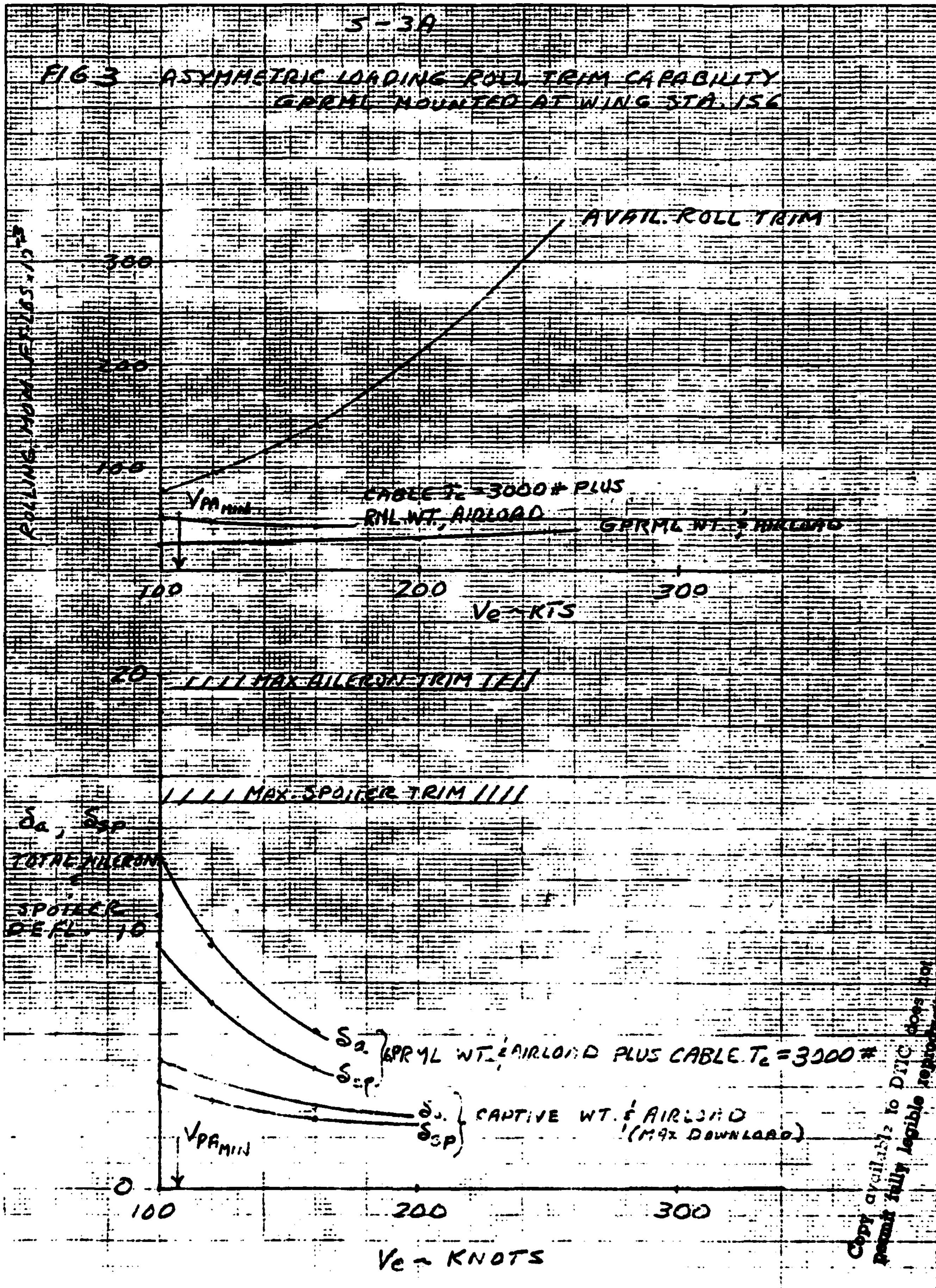
from reference (a). Launcher plus cable weight of 1,300 lbs. and target weight of 225 lbs. were used in the analysis. A maximum airload of $C_L = -.5$ (based on GPRML body planform) was also used. During towing, cable tensions of 1,500 lbs. and 3,000 lbs. (upper limit from reference (b)) acting at an angle of 4° to the fuselage reference line were examined. Results of the analysis for captive flight, normal towing and engine failure are presented in Figures 5 and 6.

As shown in Figure 5, yaw trim capability (data from reference (d)) of the F-18 is adequate for speeds above 200 kts. with a towing cable tension of 3,000 lbs. Trim moments during target captive flight are small over the speed range. Trim capability with combined conditions of engine out and cable tension of 3,000 lbs. is also adequate above about 250 kts. as shown in the Figure 5. However, it can be noted that the out of trim condition due to a cable break is considerably larger for Tc=3,000 lbs., than occurs for an engine failure. Yaw/roll transients due to a cable break in these conditions therefore would require further evaluation.

The roll trim requirements are less stringent in relation to trim capability than yaw trim as shown in Figure 6. Ample control margins are indicated over the speed range.


S-3A
FIG 1 ASSYMETRIC LOADING YAW TRIM CAPABILITY
GPRML MOUNTED AT WING STA. 156
YAWING MOMENT ~ FT-LBS x 10^3
MAX RUDDER TRIM
GPRML DRAG PLUS 3000# CABLE TENSION
GPRML DRAG
PLUS 1500# CABLE TENSION
1.4 V
BEST CRUISE
CAPTIVE FLT DRAG
0
20
40
60
80
100
120
140
160
180
200
100
200
300
Ve ~ KEAS
δR
GPRML DRAG PLUS 3000# CABLE TENSION
MAX RUDDER TRIM
V MIN
GPRML DRAG
PLUS 1500# CABLE TENSION
CAPTIVE FLT DRAG
0
10
20
10.0
200
300
Ve ~ KEAS

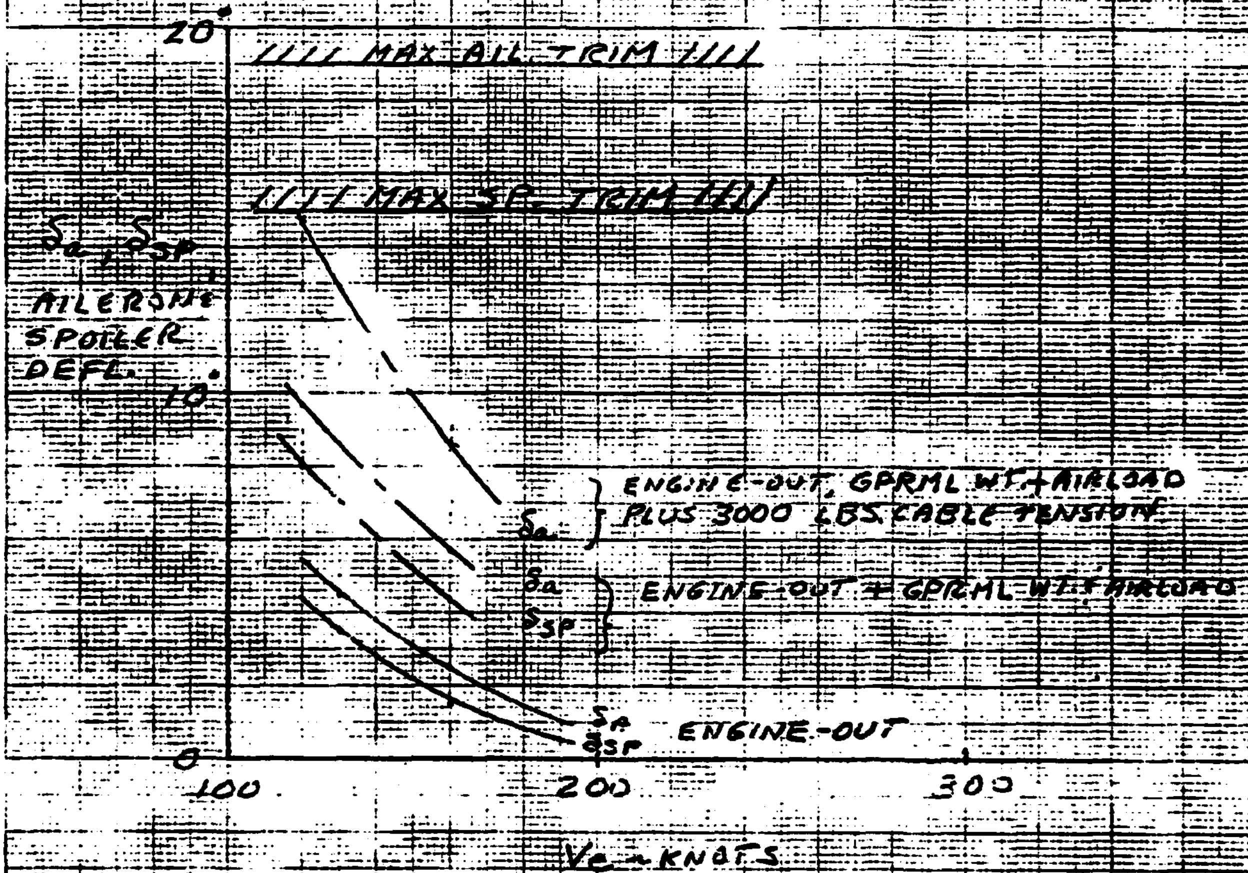

5-3A
FIG 2 ASYMETRIC POWER & LOADING YAW TRIM CAPABILITY
CONFIGURATION CR
NOTES: 1. ENGINE OUT & WINDMILLING
2. ONE ENGINE THRUST FOR LEVEL FLIGHT
3. SEA LEVEL STD DAY
4. WT = 29,000 LBS
5. RML MOUNTED AT WING STA 156
MAX RUDDER
MAX RUDDER TRIM
δ_R
RUDDER DEFL.
ENGINE-OUT PLUS GPRML DRAG & 3000# CABLE T
ENGINE-OUT PLUS GPRML & 1500# CABLE TENSION
ENGINE-OUT
TRIM INCREMENT FOR RML DRAG
24
20
16
12
8
4
0
150
200
250
300
V_E ~ KNOTS
DIETZGEN CORPORATION MADE IN U.S.A.
DIETZGEN GRAPH PAPER MILLIMETER

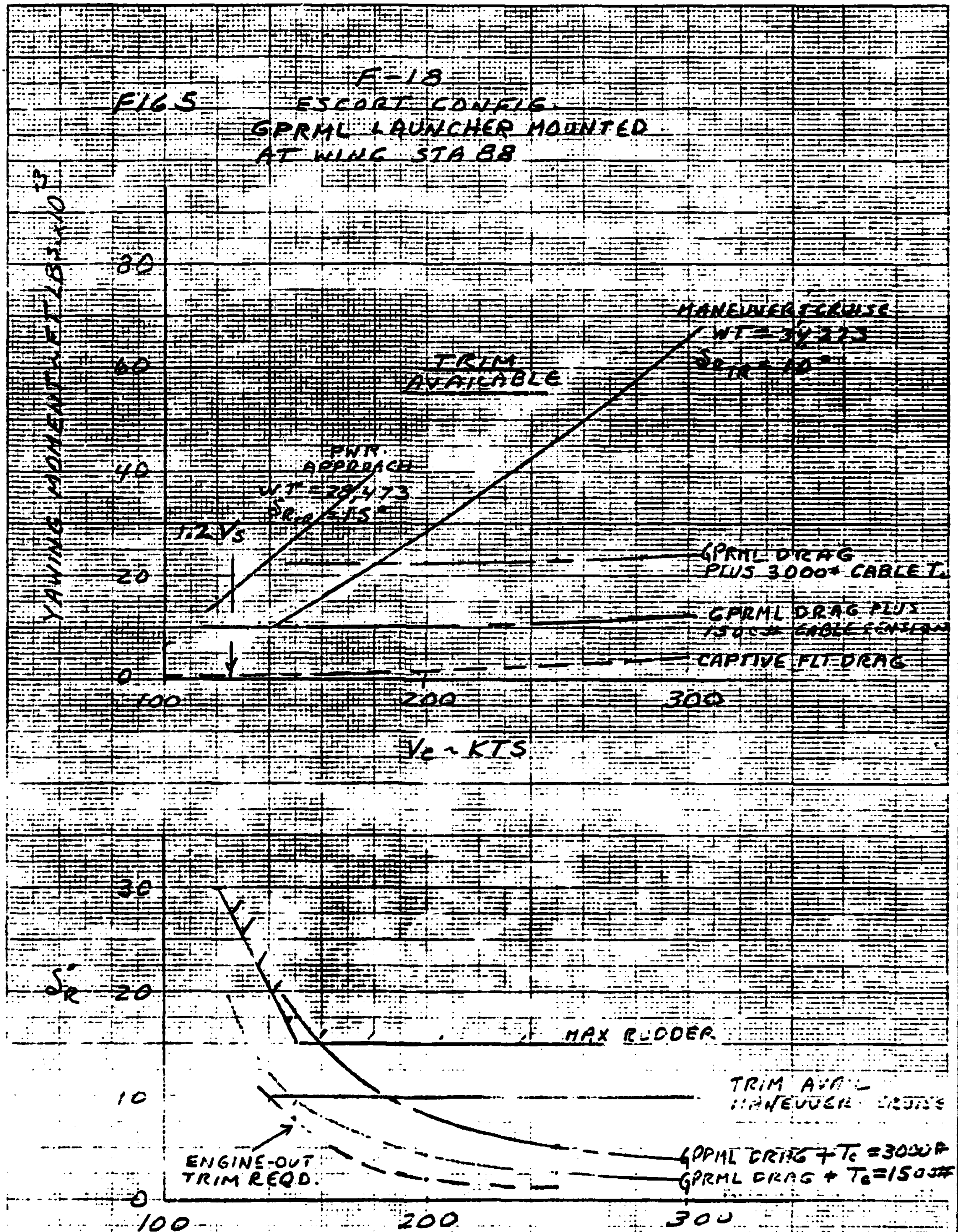

S-3A
FIG 3 ASYMMETRIC LOADING ROLL TRIM CAPABILITY
GPRML MOUNTED AT WING STA. 156
AVAIL. ROLL TRIM
ROLLING MOM. FT-LBS × 10⁻³
300
200
100
$V_{PA_{MIN}}$
CABLE T_c = 3000# PLUS
RML WT. AIRLOAD
GPRML WT. & AIRLOAD
100
200
300
V_e ~ KTS
20
MAX AILERON TRIM
MAX SPOILER TRIM
δ_a, δ_{sp}
TOTAL AILERON & SPOILER DEFL.
10
δ_a
δ_{sp}
GPRML WT. & AIRLOAD PLUS CABLE T_c = 3000#
δ_a
δ_{sp}
CAPTIVE WT. & AIRLOAD (MAX DOWNLOAD)
$V_{PA_{MIN}}$
0
100
200
300
V_e ~ KNOTS

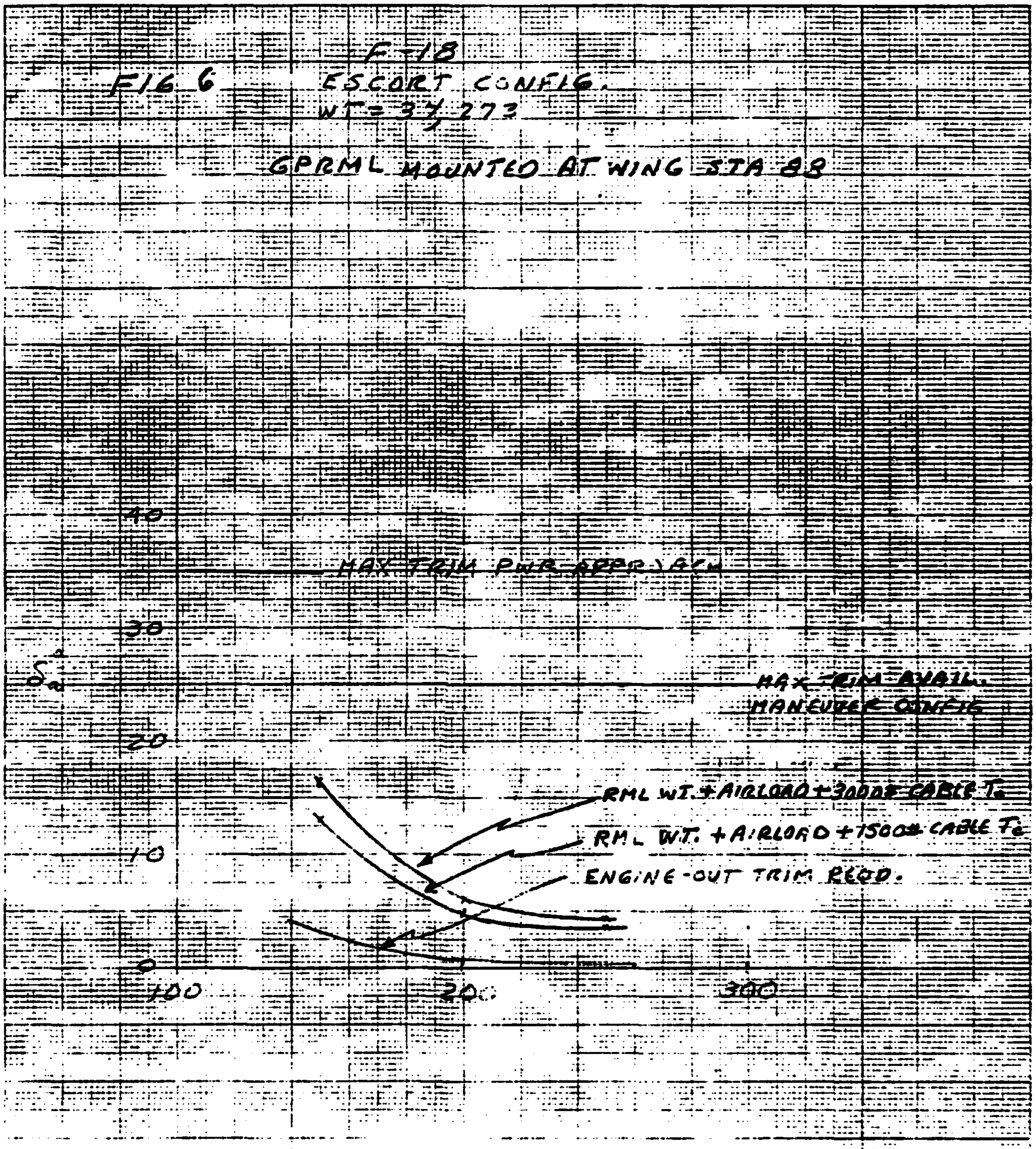
S-3A

FIG 4 ASYMMETRIC POWER & LOADING ROLL TRIM

GPRML MOUNTED AT WING STA 156




F-18
FIG 5
ESCORT CONFIG.
GPRML LAUNCHER MOUNTED
AT WING STA 88
YAWING MOMENT ~ FT LBS x 10^3
TRIM AVAILABLE
MANEUVER & CRUISE
PWR. APPROACH
1.2 Vs
GPRML DRAG PLUS 3000# CABLE T.
CAPTIVE FLT DRAG
Ve ~ KTS
MAX RUDDER
ENGINE-OUT TRIM REQD.
100
200
300


F-18
FIG 6
ESCORT CONFIG.
WT=34,273
GPRML MOUNTED AT WING STA 88
40
MAX TRIM PWR APPROACH
30
δ_a
MAX TRIM AVAIL.
MANEUVER CONFIG
20
RML WT. + AIRLOAD + 3000# CABLE T_e
RML WT. + AIRLOAD + 1500# CABLE T_e
10
ENGINE-OUT TRIM REQD.
0
100
200
300

APPENDIX B

TELCON REPORT

F-18 LIMITATIONS FOR CARRIER OPERATIONS

[redacted]TELCON REPORT
NND-NADC-3930/1 (10-66)

SUBJECT/PROJECT
Alternate Aircraft Study for Installation of NSTTS.

PURPOSE	PLACE	DATE
F-18 Limitations for Carrier Operations		7 April 1982

DISCUSSION WITH	TELEPHONE NO.(S)
Mike Branch, Strike Aircraft Test Directorate, NATC, Patuxent River, Maryland	A/V 356-4731

DISCUSSION BRIEF

☐ SEE ADDITIONAL SHEETS

The discussion involved the F-18 roll and yaw trim authority. Mr. Branch stated that the forthcoming F-18 NATOPS would establish the maximum static moment for catapult and arrestment as 15,000 ft-lb.

SIGNATURE	CODE	DATE OF REPORT
Alan Berg	6011	7 April 1982

COPY TO:

PLATE NO. 18679

APPENDIX C

TECHNICAL MEMORANDUM, Partial

A COMPARATIVE STUDY OF THE SUITABILITY OF VARIOUS NAVAL AIRCRAFT AS AERIAL TARGET LAUNCH TRACK AND CONTROL AIRCRAFT TO REPLACE THE DP-2E

NADC-82195-60

U. S. NAVAL AIR DEVELOPMENT CENTER

JOHNSVILLE, PA. 18974

AERO MECHANICS DEPARTMENT

NADC-AM-6606 22 APRIL 1966

A COMPARATIVE STUDY OF THE SUITABILITY OF VARIOUS NAVAL AIRCRAFT AS AERIAL TARGET LAUNCH TRACK AND CONTROL AIRCRAFT TO REPLACE THE DP-2E (U)

WEPTASK NO. RM4400-001/2021/S417-BO-01

This study establishes the requirement for an aircraft to replace the DP-2E currently used as an aerial target launch, track and control aircraft. The general characteristics of the equipment and the performance characteristics of the aircraft needed to meet these requirements are determined. The adequacy of several aircraft to be suitably configured is examined and their relative merits are compared.

Reported by: Robert A Rohrman

Approved by:
F. W. TOBIN
By direction

The XBQM-34E is a supersonic vehicle similar in concept to the BQM-34A. It is presently in the development stage with operational deployment planned for 1970. The supersonic speed of this target makes necessary an airborne tracking and control station which is greatly improved over the equipment presently employed. The greater speed requires faster tracking rates and more accurate position data in order to meet the needs of target positioning for missile intercepts as well as for range safety.

The AQM-37A is an air-launched, supersonic, nonrecoverable target. This target is now in service use. It is launched from fighter type jet aircraft fitted with special launch racks. The AQM-37A could be launched from several of the aircraft under consideration in this study. Besides enhancing the usefulness of the control aircraft, the addition of this capability to the target control aircraft would allow the fighter aircraft presently used to be returned to their primary mission. There is no requirement for command control since the AQM-37A follows a programmed flight path; however, it is desirable to track this target in order to determine its position relative to missile firing trajectories as well as for range safety. As in the case of the XBQM-34E, an improved tracking system is required to achieve accurate target position data.

Although the RMU-8/A reel-launcher was originally designed for towing applications on high performance jet aircraft, significant target capability may be derived from its installation on an aircraft to be utilized as a target launch and control vehicle, particularly since structural provisions for target launching equipment could be made compatible with requirements for reel mounting.

Target capability desired for special applications is summarized as follows:

Long Towline Length - Use of the RMU-8/A would permit towline lengths above 100,000 feet for use in surface-to-air missile firing exercises. The performance of a system utilizing the C-130 aircraft, used as an example, is shown in figure 2.

Formation Targets - Multiple reel installations would permit towing of up to four targets simultaneously in a predictable formation at low-altitudes.

Long Target On-Station Time - Target on-station time is limited only by the towing aircraft.

Full Size Targets - The capability of a large aircraft such as the C-130 with RMU-8/A(s) installed would permit towing of full size models of real targets.

Except for requirements relative to high-altitude and high airspeed, an RMU-8/A installation would be capable of providing the complete Navy tow target inventory including sleeves, banners, and darts with one installation.

4. Air-launching of BQM-34A targets has proven to be the most efficient means of operation. Target on-station time is increased because the launch can be made in the operating area, thus saving transit from a ground launch facility typically 50 to 100 miles away. The ability of the launch aircraft to loiter on station if operations are delayed also conserves target flight time. During airborne target checkout prior to launch, ground based instrumentation such as radio control, tracking radars, and telemetry, may be checked and calibrated, thus improving the performance of this instrumentation. An important factor helping to enhance the reliability of air-launched targets is the dynamic test made on the target during the engine runup and systems checkout prior to launch. Air-launching is a simpler operation than ground launching. There is no need to handle or store ordnance material and no need for elaborate safety precautions to protect personnel, installations, or equipment in the vicinity of the launch area.

5. An airborne target track and control station makes it possible to conduct operations beyond the range of ground instrumentation or in locations where no ground instrumentation exists. Long range missile firings and fleet training exercise far out at sea have been conducted in this manner. Low-altitude target flights are effectively tracked and controlled from an airborne station because radio horizon limitations are greatly reduced. For example, the maximum range feasible from a ground station at sea level to a target flying at 500 feet altitude is approximately 30 n. mi. From an airborne station at 10,000 feet the feasible range is 150 n. mi. For the same reasons control of surface targets is feasible. This same aircraft, if properly equipped, can perform range surveillance and frequency monitoring services as an aid to range safety. It can also be equipped to monitor target ECM, to verify its performance, and to provide ECM for nonfiring weapon system exercises. Much of this information could be relayed to a ground based mission control complex. The value of this would be to fill in information not otherwise obtainable at the ground control center. An airborne relay of target control is also possible. This would be valuable since it would provide the ground controller with more positive command of long range target operations. An aircraft so equipped for target tracking and control lends itself to adaptation to a variety of missions for experimental or tactical purposes.

6. An airborne target launching platform lends itself to a variety of uses. A simple tow target system has been perfected for the BQM-34A and could readily be adapted to the XBQM-34E. This system allows two tow targets to be deployed from the launch aircraft, then transferred to the

B. The C-130A has a proven capability to carry four BQM-34A targets based on its use by the Air Force for this purpose. The performance of this aircraft, as shown in figure 4, is more than adequate for the requirement. A 12 hour flight endurance is twice the required endurance. General arrangements of the C-130A carrying four BQM-34A, XBQM-34E, and AQM-37A targets, and four RMU-8/A reels are shown in figures 5 through 8. The fully pressurized fuselage and high operational ceiling plus a 12 hour flight endurance capability offer an optimum launch capability. The internal volume far exceeds that required for the various equipment racks and consoles necessary. A view of the internal equipment arrangement is given in figure 9. Large doors in the rear of the aircraft would permit handling this equipment in large segments which could be readily removed from the aircraft for servicing if required. The excess electrical power capacity for the C-130A is 26 KVA a.c. and 19.5 KW d.c. after allowing for the power needed to operate the basic aircraft. This is sufficient to meet the load requirements shown in table V if a portion of the d.c. power is converted to a.c. The C-130BL and C-130E models have twice the a.c. generating capacity of the C-130A and therefore will be more than adequate. The maintenance factor for this aircraft compares very favorably with other aircraft of like size and complexity. By virtue of its large load capacity this aircraft provides the unique capability of carrying several targets internally, as well as those mounted on the aircraft wings, along with a quantity of support equipment. This would permit the conduct of target operations from remote bases since all the equipment necessary for target operations, except the recovery vehicle, could be stowed in the aircraft. Little development would be required to convert this aircraft to a target launch, track, and control aircraft.

C. The P-3A rates as the highest performing aircraft of those considered. Its performance envelope, as shown in figure 10, and its 13 hour flight endurance are more than required. Only the later models have wing structures sufficiently stressed to support a target on each wing. Figures 11 through 14 show general arrangements of the P-3A carrying two BQM-34A, XBQM-34E, and AQM-37A targets and two RMU-8/A reels. The internal volume is adequate as shown by the equipment arrangement in figure 15. The electrical system provides 60 KVA a.c. excess power. The necessary d.c. power could be obtained by rectification of the more than adequate a.c. supply. The favorable aircraft maintenance factor is approximately the same as the C-130A. The fully pressurized fuselage provides a suitable environment for the operating personnel.

D. The EC-121 performance envelope, shown in figure 16, is significantly less than the C-130A and P-3A. It would be necessary to dive the aircraft in order to accelerate it to the AQM-37A launch speed. Its flight endurance of 20 hours is the longest of any of the aircraft considered. The wing structure is considered capable of supporting one target under each wing but local structural modifications would be required to adapt the launcher pylon to the wing. Figures 17 through 20 show two BQM-34A, XBQM-34E, and AQM-37A targets and two RMU-8/A reels mounted on the EC-121 aircraft. The equipment arrangement, figure 21, shows that the internal volume is more than adequate. The electrical

CONCLUSIONS

Based on the foregoing discussion, the following conclusions are made:

A. A new aerial target launch, track, and control aircraft, having improved capabilities, is required to replace the DP-2E.

B. This aircraft should be equipped to track and control aerial targets to a range of 100 n. mi. It should also perform the additional functions of range surveillance data relay and ECM as given in table I.

C. The general characteristics of the equipment required are: Weight 10,000 pounds; volume 1,000 cubic feet; electrical power 30 KVA a.c. and 10 KVA d.c. as shown in table II.

D. The performance requirements of this aircraft are: Altitude 15,000 feet for target launching, 30,000 feet for data relay; speed 200 KIAS for BQM-34A and XBQM-34E launching and 260 KIAS for AQM-37A launching; endurance 6 hours minimum.

E. The C-130A is considered the best aircraft for the purpose by a wide margin. The proven capability of the C-130A to carry four BQM-34A targets and its ability to accommodate all the required equipment with considerable room to spare are its most notable features. Multiple target presentations, presently requiring several launch and control aircraft, can be serviced by a single C-130A fitted with a multiple control system. By virtue of its large load capacity this aircraft provides the unique capability of carrying several targets and considerable support equipment internally, thus permitting operations from remote bases. Its performance and endurance are excellent and its maintenance factor is good for an aircraft of this size. It has an adequate electrical power capacity. The development effort required to modify the C-130 is lessened because of the work previously accomplished by the Air Force.

F. The later model P-3A aircraft are suitable for use as target launch, track, and control aircraft. The wing structure of earlier models is not stressed to carry BQM-34A targets. The performance of the P-3A is better than any of the aircraft considered. Its internal volume and electrical capacity are more than adequate, and it has a good maintenance factor.

G. The EC-121 ranks third on the list of aircraft considered but only because of its size. Only in internal volume does it compare with the C-130A and P-3A. Structural modification of the wing is required in order to support one target on each wing. The electrical system is barely adequate. The very high maintenance factor is also a serious disadvantage of this aircraft. For these reasons this aircraft is rated as unsuitable for the purpose.

H. The C-2A is the best of the smaller aircraft considered. It is considered capable of supporting a target on each wing, subject to a confirming flutter analysis. Except for a 7 hour flight endurance, which is adequate, the performance characteristics are nearly equivalent to the C-130A and P-3A. A comfortable excess of electrical power is available and it offers a comparatively good maintenance factor. A serious disadvantage of this aircraft is its marginally adequate internal volume and for this reason it is considered unsuitable.

I. The P-2H is equivalent to the DP-2E in load carrying capacity and as such is inadequate. The usable internal volume is insufficient and the layout is not suitable to house the equipment and personnel needed to meet even the basic requirements for target launch, track, and control in the 1970's. There is no possibility of including some of the additional functions that are desirable. Further disadvantages are its submarginal electrical power system and unpressurized fuselage which limits the practical operating altitude to 10,000 feet or less.

J. The C-1A is not adequate for use as a target launch, track, and control aircraft. The wing structure will not support the targets and the internal volume is only half that required.

RECOMMENDATIONS

1. It is recommended that a program be established to convert a C-130A aircraft to the target launch, track, and control configuration delineated in this study.

2. The P-3A is recommended as a second choice if the C-130A is not available.

3. It is recommended that the EC-121, C-2A, P-2H, and C-1A be eliminated from further consideration.

REFERENCES

(a) NAVAIRDEVCEN Rpt No. NADC-ED-5608A, "Detail Specification of the Conversion to the P2V-5FD Airplane for Launch and Control of the KDA-1 Target," of 13 Aug 1956 (conf)
(b) NAVAIRDEVCEN Rpt No. NADC-ED-5704B, Supplement No. 1A, "Modification of P2V-5FD Airplane for Launch and Control of KDA and Q-2C Targets," of 20 Nov 1961
(c) NAVAIRDEVCEN Rpt No. NADC-ED-5704C, Supplement No. 3A, "Description of DP-2E Airplane Modification, Improved Launch, Track, and Control Systems for BQM-34A and QF-9G Target Aircraft," of 2 June 1965

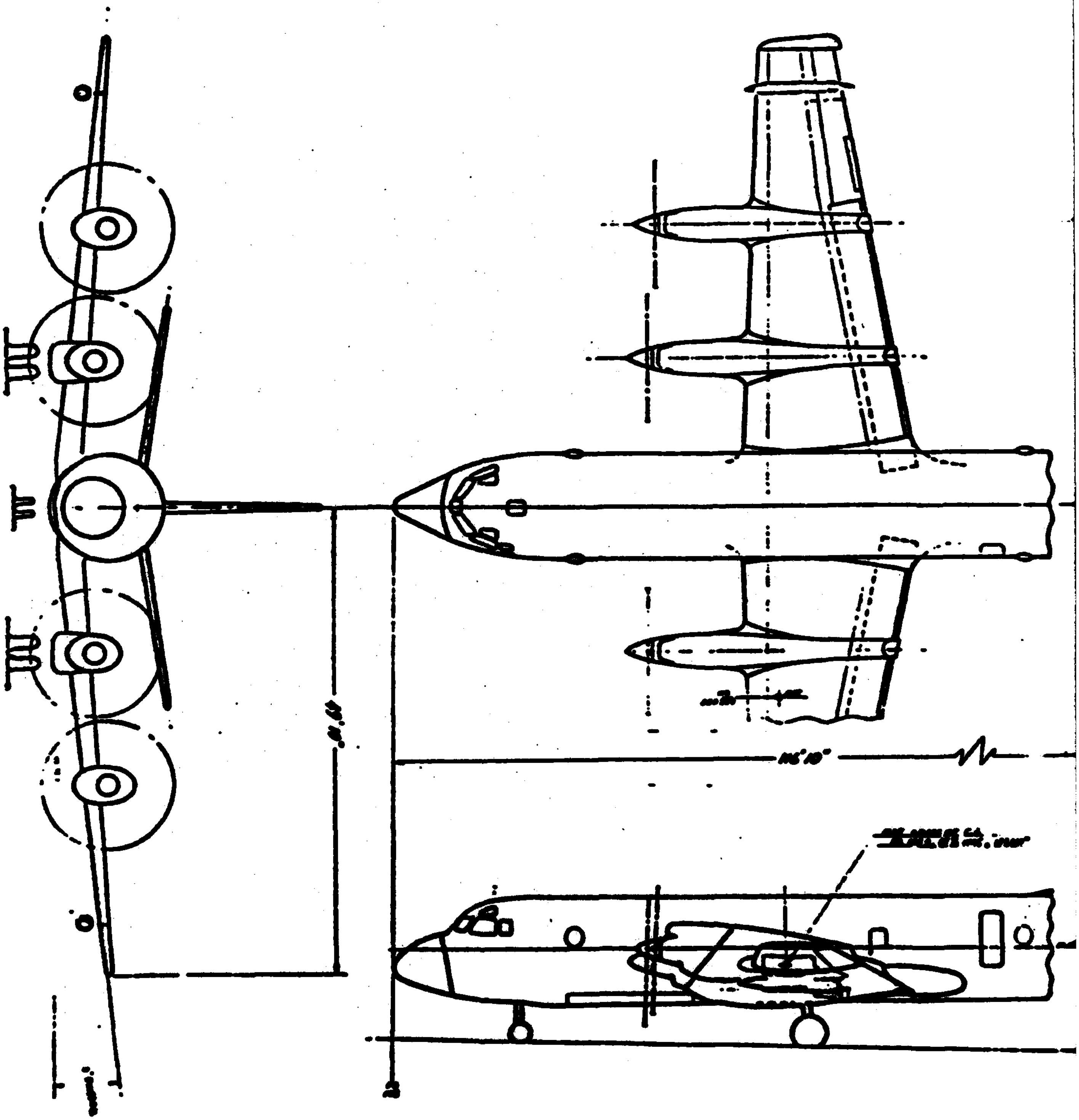


Figure 14. P-3A/RMU-8/A General Arrangement